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Volume 1

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16. ABSTRACT

This report in two volumes presents the written form and summarized discussions of "presentations" made at the Emission Inventory and Factor Workshop in Raleigh, N.C. September 13-15, 1977. A total of twenty-five "papers" on emission inventory and factor experiences and other information with emphasis on organics (hydrocarbons) were presented. Authors represented EPA, state air pollution control agencies and private industry.

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Emission Inventory / Factor Workshop

Volume 1

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September 13-15, 1977
Raleigh, NC

Co-Sponsored by
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May 1978

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FOREWORD

Emission inventories and emission factors are major components of an air pollution control program. The inventory is perhaps one of the most important planning tools available to an air pollution control agency. Emphasis on these inventories and factors, the procedures used, and the use of the information has often been lacking, however. On September 13-15, 1977, the Office of Air Quality Planning and Standards hosted a workshop with both prepared topics and open discussion in Raleigh, N. C. to focus attention to some of the aspects of such emission inventory and factor activities particularly as related to the timely aspect of organic emissions. This document constitutes the proceedings of that workshop and will be distributed to the approximately 130 attendees. Additional copies are available from EPA Library Services Office.

Papers prepared for and presented at the workshop have been finalized by the authors and are included with no additional editorial or technical modifications. Papers presented do not necessarily represent policies of the Agency but may provide a basis for development or discussion of such policies. The workshop also provided a forum for various criticism which may appear to be unanswered but hopefully helped to create an open atmosphere conducive to constructive change.

The discussions during and following the papers were condensed and edited to the extent possible. Many important discussions may have been left out due to inadequate clarity of the recording and transcription. Some of the topics of discussion may also have been more clearly addressed by the authors when the final manuscripts were prepared. It was felt, however, to be worthwhile to include the condensed discussions to indicate where the attendees felt emphasis or clarification were needed.

Following this workshop the Air Pollution Control Association's (APCA) newly formed committee; TP-7: Emission Factors and Inventories, developed plans for an APCA Specialty meeting on Inventories and Factors which will be held in Anaheim California the week of November 13, 1978, and hosted by the West Coast, APCA Section. Participants at this workshop are especially invited to submit papers for possible presentation at the meeting in California and/or be present to participate in the discussion. It has been suggested that the concept of a forum for this general topic become an annual undertaking of EPA and/or APCA. Discussion of this point and general comments on the content of this document or the need for an annual conference of some sort can be addressed to the Office of Air Quality Planning and Standards, Environmental Protection Agency, Research Triangle Park, N. C. 27711. More detail on specific papers would best be obtained by directly contacting the author(s).

As prime moderator of the workshop, I would like to express my thanks to the Air Pollution Training Institute and their contractor Northrop Services, Inc. who provided the arrangements, taping, transcription, and related work that made the workshop possible. Especially, I would like to thank the authors, co-moderators and attendees for their hard work and participation which made the workshop, I feel, to be a success.

James H. Southerland

James H. Southerland, Moderator.

Table of Contents

Emission Inventory/Factor Workshop
Volume 1

	Foreword	iii
1	Organic Emission Inventory Considerations and Purposes C.P. Bartosh, W.J. Moltz, and B.P. Cerepaka	1-1 to 1-14
2	Analysis of Data for Hydrocarbon Sources in Non-Attainment Areas in Louisiana B.C. McCoy and K.J. Guinaw	2-1 to 2-40
3	Documentation of Emission Inventories in Region IX D.C. Henderson	3-1 to 3-14
4	Methodologies and Problems Encountered in a Level 3 Multi-State/County Hydrocarbon Area Source Emissions Inventory T.A. Trapasso and W.K. Duval	4-1 to 4-26
5	Air Force Emission Inventories B.C. Grems	5-1 to 5-14
6	A Format for the Storage of Area Source Emission Data S.R. Tate, N.L. Matthews, D.J. Ames R.A. Bradley	6-1 to 6-35
7	Maryland Special Factors and Inventory Techniques E.L. Carter and J.W. Paisie	7-1 to 7-22
8	Panel Discussion of Inventory Methodology Procedures and Applications to Oxidant Control	8-1 to 8-26

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Con't From
PG VII

9 Hydrocarbon Emissions from Households in New York and New Jersey
E.Z. Finfer
9-1 to 9-20

10 Hydrocarbon Carrier Emissions from Atmospheric Dye Becks
R. Hawks
10-1 to 10-25

11 Air Quality and Energy Conservation Benefits From Using Emulsions to Replace Asphalt Cutbacks in Certain Paving Operations
F.M. Kirwan
11-1 to 11-21

12 Commercial Bakeries as a Major Source of Reactive Volatile Organic Gases
D.C. Henderson
12-1 to 12-18

13 Reactive Organic Gas Emissions from Pesticide Use in California
F.J. Wiens
13-1 to 13-53

Emission Inventory/Factor Workshop
Volume 2

14 Volatile Organic Compound Emissions From Architectural Coatings
R.A. Friesen, R.E. Menebroker, D.K. Saito
14-1 to 14-12

15 NO_x Reducations in the Portland Cement Industry with Conversion to Coal-Firing
R.J. Hilovsky
15-1 to 15-26

16 Current API Emission Measurement Programs
J.G. Zabaga
16-1 to 16-26

17 Hydrocarbon Emissions From Floating Roof Storage Tanks
R.L. Russell
17-1 to 17-22

18 Emission Inventory of Petroleum Storage and Handling Losses (A Case History)
J.T. Alexander
18-1 to 18-29

19 Inventorying Hydrocarbon Emissions From Small Gasoline Bulk Plants
R.L. Norton and R.J. Bryan
19-1 to 19-39

20 An Organic Specie Emission Inventory for Stationary Sources in the Los Angeles Area - Methodology
H.J. Taback, T.W. Sonneschen, N. Brunetz, and J.L. Stredler
20-1 to 20-49

21 Highway Motor Vehicle Emission Factors
Motor Vehicle Manufacturers Association of the United States, Inc.
21-1 to 21-80

22 FTP Emission Factor Development: Correction for Non-FTP Conditions
J. Becker and M. Williams
22-1 to 22-34

23 Land Use Based Emissions Factors
F. Benesh and T. McCurdy
23-1 to 23-27

24 Emission Rates for Biogenic NO_x
H.C. Ratsch and D.T. Tingey
24-1 to 24-28

25 Procedures for Conducting Hydrocarbon Emission Inventories of Biogenic Sources and Some Results of Recent Investigations
P. Zimmerman
25-1 to 25-32

ORGANIC EMISSION INVENTORY
CONSIDERATIONS AND PURPOSES

Presented at the 1977
Environmental Protection Agency
Emission Inventory/Factor Workshop
Raleigh, North Carolina - September 13-15, 1977

By

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Introduction

The evaluation of the causes of ambient levels of ozone and oxidants and the development of strategies for their control is one of the most difficult tasks in air pollution control. This complexity is generated not only by the diversity of the sources, but also by the varying roles an organic compound may assume in oxidant formation.

One basic approach to delineating the various factors involved in this analysis is determing the quantity, location and sources of hydrocarbon emissions. This is the general goal of a hydrocarbon emission inventory. The purpose of this paper is to define the preliminary considerations which an agency must take into account before beginning such an inventory. These considerations include a determination of the need for an inventory, the requirements of the inventory and the constraints on inventory preparation.

After these factors have been adequately considered, the mechanics of inventory preparation are complex and amenable to several approaches. This discussion is not intended to completely delineate these considerations.[1]

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[1] For a complete discussion of the methods of inventory preparation see: Bartosh, C.P., et al. Guideline Document for the Preparation of Volatile Organic Pollutant Emission Inventory. Austin, Texas. Prepared for U.S.E.P.A. Contract No. 68-02-2608. June, 1977.

*Moderators note: The above document has not been printed in bulk for general distribution. It, along with other input, was combined by EPA in EPA Publication EPA-450/2-77-028, "Procedures for the Preparation of Emission Inventories for Volatile Organic Compounds, Volume I."

Need for an Inventory

The first factor to be considered when contemplating the preparation of an organic emission inventory is why the inventory is needed or desired. Getting a firm grasp on the objective of the inventory will not only facilitate preparations of the inventory, but will also insure that after the inventory is prepared it will be an adequate and useful tool for the control agencies involved.

The reasons why an inventory may be needed can be broken down into seven basic categories. These include:

- determining overall magnitude of organic emissions,
- determine spatial and temporal distribution of organic emissions,
- determining reactivity,
- determining emission control potential,
- aiding in regulation development,
- locating ambient air monitoring sites, and
- other agency needs.

The first reason a control agency may choose to conduct an emission inventory is to determine the overall magnitude of organic emissions for a given area. Before most oxidant control strategies can be effectively developed, it is necessary to be aware of the total quantity of organic emissions being generated by all sources in the geographic area. Generally, even the most basic inventory will provide this information.

The second reason is to determine spatial and temporal distribution of organic emissions. In some cases, an agency may feel that knowing the total annual emissions within a large geographical area may not be sufficient. Instead, it may be necessary to know more accurately where and when the emissions occur. An example of such resolution would be to determine organic emissions within a square mile grid on a daily basis. This resolution might be a needed result of the inventory where the agency feels that the oxidant problem is localized and should be analyzed carefully for a specific oxidant season.

A third possible objective of an organic emission inventory is to determine the reactivity of emissions. Although most organic compounds which are emitted into the atmosphere ultimately engage in a photochemical reaction, some compounds are more reactive than others and have a quicker, more localized impact upon air quality. The various reactivity schemes which have been developed to quantify this effect vary from a simple methane/nonmethane classification to the more complex multiple-class reactivity scheme. By breaking down organic emissions by reactivity within the inventory, an agency may be able to develop a more comprehensive and discriminating oxidant control strategy.

A fourth need which may be satisfied by an organic emission inventory is the determination of emission control potential. An inventory can provide this capability by collecting information on the degree and type of emissions control currently in use and the magnitude and location of sources which are amenable to greater control. This information can be very valuable to an agency in determining what additional controls would be feasible within the oxidant strategy. It would also provide this capability for an agency to superimpose various control scenarios and determine their affects. A third possible use would be to monitor changes in control equipment to determine compliance levels.

The fifth possible need which could be met with the inventory is to provide the necessary emissions data for regulation development. Although other considerations, such as economic and social impacts, must ultimately be evaluated, an inventory can provide valuable information on which sources could be subjected to control requirements and what the ultimate effect on air quality the emission standards would have. The inventory would also be useful in determining the effect upon air quality of new sources and aid in the formulation of the required emission standards. In addition, the inventory data would be useful in the formulation of regulations not involving specific emission standards such as urban vehicular traffic control.

A sixth purpose for which the inventory could be used is locating sites for ambient air monitoring. The emissions data collected by an inventory can be used along with existing meteorological data and ambient air measurements to predict suitable sites for future monitoring. This capability could be useful both in ascertaining current violations and as part of future maintenance activities.

The final needs which may be met by an inventory are the general localized agency needs. Examples of such needs include continued monitoring of industry growth and trends through inventory updates, maintaining current data on existing sources and reporting obligations to other agencies. In this regard, an organic emissions inventory design should be flexible to provide whatever additional information may be desired.

These seven general objectives only give a basic overview of the needs which can be met through the capabilities of an organic emissions inventory. If sufficient resources are available, the information supplied by a well conducted inventory can be very sophisticated and provide invaluable input into the formulation of a comprehensive oxidant strategy. The inventory objectives and the level of resolution, however, must be carefully delineated prior to inventory designs. They should also be constantly reevaluated in light of information determined during development.

Inventory Requirements

After the overall inventory goals have been determined, it is necessary to develop the basic planning and design of the inventory. It is at this stage that the general requirements of the inventory must be delineated and the constraints determined.

The first requirement which must be determined for all inventories is the geographical area to be inventoried. The overall size of the area to be inventoried can vary from the entire nation to one small subsection of a city or county. The most important consideration here is not how large an area can feasibly be inventoried, but instead, how small an area can be inventoried and still provide adequate information.

Another requirement which must be specified in the inventory design is spatial and temporal resolutions. That is, how much accuracy is desired with regard to when and where emissions occur. This resoltuion will generally vary between the large stationary point sources and the more generalized area sources, but should be defined sufficiently to insure that adequate data is acquired. The spatial resolution procedure generally used is to pinpoint the location of point sources using UTM coordinates and apportion the area sources evenly over small grid areas. The temporal resolution generally used is emissions on an annual basis with some data given on seasonal variations. There is, however, great flexibility in the spatial and temporal resolutions of an inventory. For example, the resolution can vary from annual totals for a large area to time of day data from specific point sources. The only requirement is that the final inventory will satisfy the agency needs.

If is has been determined that the purpose of the inventory includes the need for a reactivity breakdown of emissions, it is necessary at this point to define the level of breakdown to be used. As was mentioned earlier, there are several different reactivity schemes which can be used. Ideally, an agency could assign every different organic compound a reactivity index and compile a very comprehensive reactive hydrocarbon emission inventory. This approach, however, would generate extremely large amounts of data and would be quite cumbersome to work with. Instead, the agency should decide on some limited grouping of hydrocarbons, and thereby develop a simplified inventory.

Once it has been determined which area will be inventoried and what general type of data are needed, the agency must consider what source specific data is required. This type of data includes specific location of stack, stack parameters, process data, control device information and many other characteristics of particular sources. In addition, the accuracy of the desired data must be considered in order to maximize the accuracy of the resulting inventory. This is a very critical step in that this type of data will generally come from the sources themselves, and, therefore, large amounts of data and contacting may be involved. For example, if twenty questions must be asked of 1000 sources, 20,000 pieces of data will be generated. It must be remembered, therefore, that this type of data acquisition is very taxing upon resources and must be carefully considered in light of the overall purpose of the inventory.

Another consideration which should be examined with regard to the data which will be gathered is the status of any existing inventory. This is a major consideration, especially if the agency is faced with limited resources. It may be possible to merely modify or update an existing inventory for use in the oxidant control program since there will be no need to reobtain good data. At the very least, an existing inventory may provide a good starting point for the preparation of a new inventory. No specific guidance can be offered here as each existing inventory and agency needs will vary, but these considerations generally involve a balancing of what the agency has, what the agency wants and the resources available.

After it has been determined just what data is needed and what the scope of the inventory is to be for the oxidant control program, the agency should determine what other needs it has which could be met simultaneously or made compatible with the organics inventory. An example of such a simultaneous program would be a corresponding nitrogen oxides inventory. Since, along with organics, nitrogen oxides are a precursor to photochemical oxidants it may be desirable to have a current NO_x inventory as input to the oxidant control program. The NO_x inventory can be conducted most effectively by including it with the organics inventory. Another such factor which should be considered is the possibility of designing the inventory to serve as input to, or interface with, other existing systems such as photochemical simulation models, compliance systems and EPA's National Emissions Data System. It should be remembered when planning these interfaces that designing the inventory to provide data which is consistent both in content and units will facilitate any interaction.

At this point the agency should have specified all the basic purposes, needs and interfaces of the inventory. The next step is to define the means by which the data will be handled. The two basic approaches to data handling and retrieval are manual and computer. The considerations which go into the determination of which approach to use are availability of a computer, volume and complexity of data handling, availability of personnel, and time constraints. The methods of data handling and retrieval should generally be selected early in the inventory design to insure that methods and data format are compatible with the system to be used.

Inventory Constraints

The third and final major consideration which must be evaluated in the development of an organic emission inventory are the constraints and the available resources. These factors include time, manpower, facilities and funds. Each of these factors must be carefully examined to ensure that they are consistent with the requirements of the inventory which have been developed.

In summary, before beginning the compilation of a comprehensive organics emission inventory it is first necessary to outline the basic agency needs and goals in light of the agencies oxidant control program or other data needs. The second step is to outline the specific requirements of the resulting inventory and insure that all requirements will be met by the acquired data. The third step is to insure that the goals and the methods chosen are feasible within the constraints upon the inventory preparation. In addition, as work progresses these factors must be continually reviewed to guarantee that all of the program's objectives are met within the program's constraints. If these criteria are carefully monitored and adhered to, the resulting organics emissions inventory should be a very useful tool in the development of a comprehensive oxidant strategy or other agency programs.

CONDENSED DISCUSSION

Question: I would like to ask the moderator what EPA plans as far as distribution of the hydrocarbons guideline document mentioned?

Moderator: We are currently editing and revising the document and will circulate it to various people in the regions and other offices and we intend to publish it before the end of the year. I hope that the document will be ready for distribution sometime in October or early in November, but this depends on review comments, etc.

Question: I wonder if Mr. Bartosh would take a minute to elaborate on any feelings on reactivity and how far one should go at definition of reactivity in an emission inventory. I think you gave a fairly general feeling that it generally would be satisfactory to stay with nonmethane. Should one try and be more specific?

Bartosh: I think I should defer that question to Mr. Ed Lillis or the moderator since I think that speaks more of a policy issue which I am not prepared to respond to on behalf of the EPA.

Moderator: I think it's best policy and common sense to collect no more information than you need and are going to use. Also, when you are doing an emissions inventory you need to consider the effect on the sources of soliciting various kinds of information, and the extent of your own (agency's) resources and this kind of thing. I think a general statement would be that if you are going to use a model which requires reactivity then it is worthwhile to break the inventory up into the various classes and these classes should be dictated by the specific model that you choose. I think for most situations that will arise for some time, adherence to the nonmethane distinction will be sufficient for the need, however.

Ed Lillis: I tend to agree with that. We are getting basically into EPA's thinking with respect to the reactivity of volatile organic compounds (VOC) rather than just the general procedural techniques. I would add one more thing. Probably in two to four years from now, there will be greater use of atmospheric photochemical oxidant models than there is right now. At that time, the use

CONDENSED DISCUSSION (CON'T)

Ed Lillis: (con't) of reactivity information will be more useful and necessary. Some thinking and planning has begun in the area of ways to select basic information on reactivity and some ways of sorting and using the information after you get it. But at the present time, I would think, in general, that Jim suggesting the use of a nonmethane breakdown or including other compounds that do not react should be adequate.

Question: How does this advice relate to the published reactivity guides of EPA and how do you relate to those two pieces of guidance.

Moderator: I guess I should probably have been a little more specific in my terminology of nonmethane. I more or less included the other five compounds in the nonmethane terminology without being specific to clarify that. The compounds as listed in the July 8th Federal Register announcement constitute the formal definition between reactive and nonreactive.

Audience Comment: It is my understanding there is recent guidance that came out of the regional offices saying that potentially toxic but nonreactive compounds should be excluded from the base line and not considered for control purposes.

ANALYSIS OF DATA FOR HYDROCARBON SOURCES IN NON-ATTAINMENT AREAS IN LOUISIANA

Presented at the 1977
Environmental Protection Agency
Emission Inventory/Factor Workshop
Raleigh, North Carolina - September 13-15, 1977

Presented by William Piske

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ABSTRACT

Photochemical oxidant (O_x) air quality data obtained during 1975 in the Louisiana portion of the Southern Louisiana-Southeast Texas Interstate AQCR (No. 106) indicated a possible need for revisions to the hydrocarbon control strategy portion of the approved Louisiana State Implementation Plan. This paper summarizes the methodologies and results of a comprehensive review of the adequacy of the control strategy. The analysis included: (1) preparation of detailed emission inventories for both total hydrocarbons (THC) and non-methane hydrocarbons (NMHC) and projections of these inventories to future years; (2) a thorough evaluation of the status of compliance of existing stationary hydrocarbon sources with applicable Louisiana regulations; (3) projection of O_x air quality to future years; and (4) recommendations for control strategy revisions, if such are called for. The present paper emphasizes task (1), the emission inventory compilation and projection aspects of the overall study.

Primarily because of exemptions granted for several classes of organic compounds by the State regulations, the hydrocarbon control strategy was found to be inadequate. Alternative strategy revisions recommended for further study include: (1) revocation or partial revocation of the emission exemptions; (2) ship and barge loading evaporative controls; and (3) installation of Stage II vapor recovery controls at retail gasoline outlets.

1.0 INTRODUCTION

1.1 BACKGROUND

The Clean Air Act requires that State Implementation Plans (SIP's) provide for revisions on the basis of: (1) revisions of the national ambient air quality standards (NAAQS) or the availability of improved control measures; or (2) a finding by the Administrator that a plan is substantially inadequate to achieve the NAAQS for which it applies. The present study was an immediate consequence of the latter requirement.

The control strategy portion of the Louisiana SIP for photochemical oxidants (O_x) and hydrocarbons (HC) in the Louisiana Portion of the Southern Louisiana-Southeast Texas Air Quality Control Region (AQCR 106) was approved in July, 1973. However, in 1975, two events having special significance with regard to the AQCR 106 oxidant issue, occurred:

- Photochemical oxidant levels in 1975 were found to be even higher than those observed in 1973, in spite of decreases in hydrocarbon emissions from many large sources in the years 1973, 1974 and 1975.
- Recent data available to EPA indicated that virtually all organic compounds are photochemically reactive and can react to form photochemical oxidants.

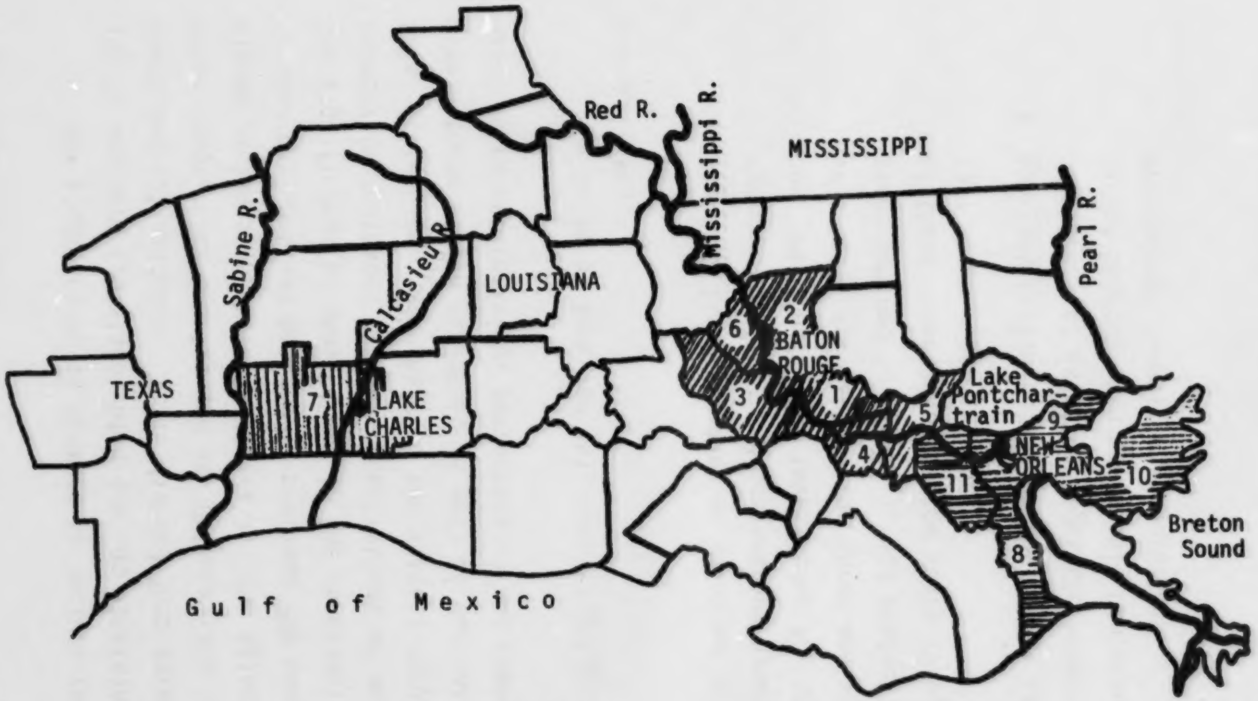
These occurrences resulted in a need for a reevaluation of the Louisiana SIP for photochemical oxidants/hydrocarbons. TRW Environmental Engineering Division was retained by the EPA Region VI Office to perform the reevaluation, which is summarized in this paper and presented in detail in reference 1.

1.2 SCOPE OF WORK

The study region is defined to include those portions of AQCR 106 in southern Louisiana which are not attaining the NAAQS for photochemical oxidants. It is divided into three analysis areas--Baton Rouge, Lake Charles and New Orleans--and is comprised of eleven parishes as shown in Figure 1. The selection of these particular parishes was based on a previous TRW study of AQCR 106.[2] The significance of these areas in the functioning of the state's economy is indicated by the concentrations of population and industrial activities. Over half of the state's population is contained within these eleven parishes, as well as the heart of its industrial base--petroleum refining, petrochemical and chemical operations.

The Scope of Work for this investigation included the following substasks:

- Sub-Task 1--Preparation of detailed total hydrocarbon (THC) and non-methane hydrocarbon (NMHC) emissions inventories for the year 1975, for each of the three analysis areas defined in Figure 1, and projection of these inventories to the years 1976, 1977, 1978, 1980 and 1985.
- Sub-Task 2--Evaluation of the status of compliance of existing regulated hydrocarbon sources with applicable Louisiana Air Control Commission regulations.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BATON ROUGE
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1
4
5
Lake Pontchartrain
9
NEW ORLEANS
11
10
8
Breton Sound
Gulf of Mexico

ANALYSIS AREAS: ▨ BATON ROUGE ▥ LAKE CHARLES ▤ NEW ORLEANS

Parishes :	BATON ROUGE	LAKE CHARLES	NEW ORLEANS
	1 Ascension	7 Calcasieu	8 Jefferson
	2 East Baton Rouge		9 Orleans
	3 Iberville		10 St. Bernard
	4 St. James		11 St. Charles
	5 St. John the Baptist		
	6 West Baton Rouge		

FIGURE 1

SOUTHERN LOUISIANA--SOUTHEAST TEXAS INTERSTATE AQCR (106)

- Sub-Task 3--Projection of photochemical oxidant air quality levels to the years 1976, 1977, 1978, 1980 and 1985.
- Sub-Task 4--Determination, on the basis of the previous sub-tasks, of the need for revisions to the Louisiana hydrocarbon control strategy and, if revisions are needed, the provision of alternative strategy revisions.

This paper is based primarily on Sub-Task 1, the preparation and projection of emission inventories.

2.0 EMISSION INVENTORY AND PROJECTION TECHNIQUES

2.1 GENERAL APPROACH

The purpose of this Section is to discuss the methodologies and assumptions used to develop 1975 baseline and projected future emissions inventories of both total hydrocarbons (THC) and non-methane hydrocarbons (NMHC) in each of the three analysis areas. The baseline emissions inventories were developed by making use of two basic approaches:

1. For major sources, industrial and commercial point sources, the comprehensive Louisiana Air Control Commission (LACC) files provided explicit emissions data via the Emission Inventory Questionnaire (EIQ) required by law from each source.
2. For other sources, such as transportation and area sources, it was necessary to estimate emissions by multiplying an activity factor by an emission factor, which is a measure of the quantity of emission per unit of activity. Activity factors used in the present study are listed in Table 1.

Once the baseline emissions inventory was developed, it was necessary to project the emissions to the later years of interest. Here, there were three basic approaches:

TABLE 1

TYPES OF DATA USED FOR ESTIMATING AND PROJECTING HYDROCARBON EMISSIONS

Source Category	Activity Factor	Projection Factor
I. Area		
A. Drycleaning	Tons of dry cleaning	Extrapolation of historical industry growth rates
B. Solvents	Population	Population
C. Space Heating	Fuel Consumption	Population
II. Point		
A. Chemical	None. Based on EIQ's	Permit applications to 1977. Projected earnings afterwards.
B. Electricity Generation	Fuel usage from EIQ's	Population
C. Petroleum Refining	None. Based on EIQ's	Permit applications to 1977. Projected earnings afterwards.[a]
D. Ship & Barge Loading	Liquid organic commodities traffic	Projected earnings of involved industries
III. Transportation		
A. Motor Vehicles	Vehicle miles of travel	Extrapolation of historical trends
B. Off-Highway Fuel	Gasoline sales & outboard motor registrations	Extrapolation of historical trends
C. Aircraft	Landing/takeoff cycles	Extrapolation of historical trends
D. Railroads	Fuel use	Projected earnings in the railroad industry.
E. Vessels	Fuel use	Trend extrapolation of waterborne commerce
F. Gasoline Marketing	Gasoline sales	Extrapolation of historical trends

[a] The Baton Rouge Analysis Area is an exception; in this AA, EIQ's from permit applications were used for all petroleum refining projections.

1. The EIQ's which must accompany permit applications for new or modified sources were used for industrial point sources so far as possible.
2. In some cases, historical growth trends were used to project emissions.
3. In other cases, the emissions were assumed to be proportional to some economic or demographic variable for which projections were available. Projected constant dollar earnings were the variables of choice, since they correct for both inflation and productivity changes in most cases.

The methods used to project each of the source categories of this study are also given in Table 1. The remainder of this Section discusses the emissions estimation and projection methodology for each source category in detail. Categories for which everyday techniques were used are only briefly described, and most of the emphasis is placed on those categories having some novel or uncommon features.

2.2 AREA SOURCES

Three types of hydrocarbon area sources are present in the three analysis areas:

- Dry cleaning plants
- Other solvent consumption

- Commercial and residential space heating

The methodology for each source follows, in the above order.

2.2.1 Dry Cleaning Plants

The approach used in estimating emissions from these sources was as follows:

1. An estimate of the total 1975 volume of dry cleaning performed in Louisiana was made by multiplying the number of commercial and industrial plants by typical annual cleaning volumes for each plant type. The data required were taken from a recently completed study of the industry.[3]
2. In accordance with opinions expressed by several industry representatives, it was assumed that about fifty percent of the total cleaning volume was handled using petroleum solvent and that fifty percent was handled using perchloroethylene.
3. Emission factors from reference 3 were used to estimate the emissions from each plant type, because they were the most current factors available.
4. The statewide emissions of each solvent were apportioned to the three analysis areas by using 1975 county population

data available from a recently completed study by the University of New Orleans.[4]

5. Emissions were then projected to later years using commercial plant and industrial plant growth rates, respectively, for perchloroethylene and petroleum solvent emissions.* Growth rates from reference 3 were used.

2.2.2 Other Solvent Losses

This category includes solvent evaporation from vapor degreasing, cold cleaning, surface coating and other miscellaneous operations. The approach was that provided by EPA in the emissions inventory guide.[5] This method entails only the multiplication of county populations by emission factors, which are themselves functions of population. Both 1975 and projected population data were based on a recent University of New Orleans study,[5] and are believed to be the most representative data available. In accordance with LACC regulation 22.9, emissions from these sources were reduced by 90 percent after making the gross estimates.**

2.2.3 Commercial and Residential Fuel Use

Residential and commercial fuel consumption data from a recently completed study[6] covering all of Louisiana were provided by Dr. Paul H. McGinnis, Jr., of the Louisiana Department of Conservation. Fuel use was categorized by type--natural gas, distillate oil, and liquified petroleum gas (LPG)--for twelve consumption sectors covering the state. Only one of these sectors (Lake Charles) coincided with the analysis areas used in the present study. The following approach was used to disaggregate and reapportion the emissions from the consumption sectors into the appropriate analysis areas:

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*Most industrial cleaning utilizes petroleum solvent and most commercial cleaning utilizes perchloroethylene.

**This regulation requires a 90% emissions reduction for uncontrolled solvent users emitting more than 15 pounds per day.

1. First of all, the total emissions were calculated for each consumption sector which contained one or more parishes belonging to an analysis area. AP-42 emission factors were used.
2. It was then assumed that these emissions were proportional to population. The 1975 baseline parish population data were used to "select" those emissions which "belonged" to each analysis area.
3. The "selected" emissions for each analysis area were then totaled to approximate the 1974 emissions expected in each analysis area.

Projections to 1975 and later years were made on the basis of population growth rates.* The non-methane content of these emissions was assumed to be zero, as a result of combustion test results from a petroleum refinery.[7]

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*This implicitly assumes that the relative rates of energy consumption between sectors do not change, as well.

2.3 POINT SOURCES

The point sources of importance in Southern Louisiana include: (1) chemical plants, principally petrochemical operations; (2) electricity generation; (3) petroleum refining operations; and (4) ship and barge loading. There were some sources, such as combustion sources, shipyards, and other miscellaneous sources, which were too small and diverse to justify separate categories. Such sources were placed in the "Chemical/Manufacturing" category.

With one exception, the emissions from all point sources were obtained from the Emission Inventory Questionnaires (EIQ's) in the LACC files. There were insufficient data on hand for the "Ship & Barge Loading" category to be handled in this way, and these emissions were estimated using an area source approach. However, from a control standpoint, these sources should be considered point sources, because the emissions appear to be significant.

2.3.1 Chemical and Manufacturing Industries

As noted previously, the 1975 baseline emissions for this group of sources were obtained from the EIQ's, and in most cases, the chemical plants provided estimates of both total and non-methane hydrocarbon emissions. Some sources were contacted by LACC personnel to obtain additional data, but, for the most part, the EIQ's provided adequate information.

It was assumed that the non-methane content of the emissions from combustion sources was zero, on the basis of information obtained from burner tests at a refinery.[7] Prior to obtaining this information, the Monitoring and Data Analysis Division of EPA was contacted to determine whether any data on the methane content of any AP-42 emission factors were available from EPA, but the reply was negative.

For sources which were not in compliance with the Louisiana hydrocarbon regulations, it was necessary to determine when they would come into compliance, and what the schedule was for reducing emissions to the required level. This information was needed for projection purposes. In some cases, a projected EIQ was available for this purpose, but in others, it was necessary to peruse the entire Compliance Schedule (CS) file to obtain the compliance status and the emissions levels expected.* Most sources were legally in compliance, but numerous sources had made use of either specific exemptions written into the regulations or had obtained variances from the Commission after public hearings, and specific note of the nature and magnitudes of the variances were made in the study.

Prior to either starting a new source or increasing the emissions from an existing source, the operator must submit a permit application to LACC and obtain approval to operate. Such an application must be accompanied by a new or revised EIQ. These applications are made some time before the change is to take place, so it was assumed that all growth through 1977 would be covered by the EIQ's accompanying permit applications.

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*LACC operates a compliance data system (CDS) which is useful for determining the overall compliance of sources, but it had two shortcomings for the present purpose: (1) the CDS evaluation was for 31 March 1976, and many sources had reduced their emissions in late 1975 or early 1976, so they were out of compliance during most of 1975, the baseline year; and (2) if a source was out of compliance, a pollutant other than hydrocarbon might be responsible. Such problems could only be resolved by a thorough search of the compliance files.

For growth after 1977, it was assumed that emissions were proportional to projected earnings in the chemical and allied products industry. The data were obtained from the 1972 OBERS projections,[8] and were the only such data found during the study. Examples of the formats developed for indicating overall hydrocarbon emissions and compliance status (Table 2) and the effects of exemptions and variances (Table 3) are shown.

2.3.2 Electricity Generation

Emissions from power plants were estimated by the use of AP-42 emission factors and the fuel use data provided on the EIQ's. NMHC was assumed to be zero, for reasons discussed previously.

No permit applications were found for power plants in any of the three analysis areas, so it was necessary to use growth factors for projection purposes. It was assumed that the growth in electrical demand would parallel population, and population projections were obtained from the recently completed study by the University of New Orleans.[4] An additional assumption was that all additional power generation would be by means of fuel oil to add some conservatism to the projections.

2.3.3 Petroleum Refining

Emissions from refineries were obtained directly from the EIQ's. However, most refineries based their estimates on AP-42 emission factors, which yield THC, and it was necessary to contact many of these sources to obtain estimates of the methane content of the total hydrocarbon emissions. In cases where the refinery personnel did not know the methane content, the data below--provided by Shell Oil Company--were used:[7]

TABLE 2

POINT SOURCE HYDROCARBON EMISSIONS AND COMPLIANCE STATUS[a] - BATON ROUGE ANALYSIS AREA

Parish/Source	1975 Emissions(t./yr.)		Expected Emissions(t./yr.)[b]			Compliance Status
	THC	NMHC	Year	THC	NMHC	
ASCENSION						
BASF Wyandotte Geismar Works	590	572	n.a.	n.a.	n.a.	In compliance
Borden Chemical VCM & Organics	1,389	1,362	1976 RFC	836 619	819 591	Post attainment date problems
CF Industries Donaldsonville Complex	1,873	1,848	1977	5,284	5,058	In compliance
Evan Hall Sugar Coop.	1	0	1976	1	0	In compliance
Melamine Chemicals Inc.	2	0	n.a.	n.a.	n.a.	In compliance
Monochem, Inc.	472	455	n.a.	n.a.	n.a.	In compliance
Rubicon Chemicals	71	70	n.a.	n.a.	n.a.	In compliance
Shell Chemical Company Geismar Plant	1,038	559	n.a.	n.a.	n.a.	In compliance
Shell Oil Company Tebone Plant	282	280	n.a.	n.a.	n.a.	In compliance
Triad Chemical	85	64	n.a.	n.a.	n.a.	In compliance
Uniroyal Chemical Division	1,995	1,995	1976	1,570	1,570	In compliance
Vulcan Chemicals Geismar Plant	4,865	4,863	n.a.	n.a.	n.a.	In compliance

[a] Abbreviations: THC=total hydrocarbon; NMHC=non-methane hydrocarbon.

[b] "Expected emissions" are emission projections provided by the source via the E.I.Q. When unavailable, such is indicated by "n.a." (not available).

TABLE 3

EXEMPTED HYDROCARBON SOURCE SUMMARY - BATON ROUGE ANALYSIS AREA

PARISH/Company/Source	SOURCE CATEGORY	1975 EXISTING EMISSIONS (TPY)	POSSIBLE REDUCTION		REMAINING EMISSIONS (TPY)
			%	TPY	
ASCENSION					
BASF Wyandotte Geismar Works					
- Glycol Concentrator	Vent	44	90	40	4
- 3 CO_2 Strippers	Vent	438	95	416	22
- Weighing & Reactor Systems	Vent	53	90	48	5
Borden Chemical VCM & Organics					
- VCM Vent Scrubber*	Vent	796	50	398	398
- EDC Storage Tanks	Tank	88	90	79	9
- VnAc Storage & Loading	Tank	164	90	148	16
CF Industries Donaldsonville Complex					
- 5 NH_3 Plant Vents	Vent	1,848	95	1,756	92
Monochem, Inc.					
- Acetylene Cooling Tower	Fugitive	455	50	228	227
Rubicon Chemicals					
- Sulfuric Acid Stack	Vent	70	90	63	7
Shell Chemical Company Geismar Plant					
- CO_2 Vent	Vent	420	95	399	21
- Cooling Tower	Fugitive	362	50	181	181
- Vent & Stack	Vent	75	90	68	7
- Vents 8-71 & 9-71	Vent	42	90	38	4

* This source already has some controls in place, which is reflected in an adjustment to the possible reduction.

** The possible reductions for these sources are based on existing compliance agreements or other information provided by the particular source or another similar source.

- Total Refinery Emissions--4.5% methane
- Crude Handling Emissions--4% methane
- Combustion Emissions--100% methane

Compliance data were obtained from the LACC files, exactly as described for chemical plants.

Projections to 1977 and earlier years were based on the EIQ's accompanying permit applications. In the Baton Rouge Analysis Area, permits have been approved for two large new refineries, only one of which is presently under construction. Hence, all growth in this area was assumed to be accounted for by these two sources.

In the other two analysis areas, no explicit emissions projections were available after 1977, so it was necessary to use growth factors for later years. Projected constant dollar earnings for the petroleum industry were used to make the projections. The data came from 1972 OBERS Projections.[8]

2.3.4 Ship and Barge Loading

The loading of organic liquids from chemical plants and petroleum refineries may result in significant hydrocarbon emissions if not controlled properly. The first step in the process of estimating hydrocarbon emissions from ship and barge loading operations is to quantify the amount of organic liquids shipped in each analysis area. Data on the amount of organic liquid commodities handled on the waterways within each analysis area were available from the U. S. Army Corps of Engineers for 1974.[9] In cases where the boundaries of a waterway segment, for which shipping data were supplied, did not correspond to or fall within the boundaries of the analysis area, traffic was apportioned by the length of the segment located within the analysis area boundaries. The amounts of organic commodities shipped in 1975 and future years were projected using estimates of future earnings in the chemical and petroleum industries made by the 1972 OBERS Projections.[8]

The second step in estimating emissions from ship and barge loading is to multiply the commodities loaded by an emission factor. The organic commodities loaded in each analysis area were aggregated into two groups, those related to chemical plants and those related to petroleum refineries. Alcohols (SIC 2813), benzene and toluene (SIC 2817) were grouped as chemical plant products, and all other commodities were considered petroleum refinery products. Emission factors developed for all products loaded from petroleum refineries ($2.01 \text{ lb}/10^3$ gal) and for all products loaded from chemical plants ($1.2 \text{ lb}/10^3$ gal) in the oxidant control strategy for Texas were utilized.[10] These emission factors, which were assumed to be typical of petroleum refinery and chemical plant loading operations in Texas, are assumed to be representative of the same operations in Louisiana.

2.3 TRANSPORTATION SOURCES

Hydrocarbon emissions from transportation-related activities are divided into the following six source categories:

- Motor vehicles
- Off-highway fuel use
- Aircraft
- Railroads

- Vessels
- Gasoline evaporation

The methodology for the transportation sector is based primarily on that given in two references[5, 11] so the following discussions are relatively brief, except for certain areas of special interest.

2.3.1 Motor Vehicles

Vehicle Miles of Travel - VMT data were available from the Louisiana Department of Highways for roadways comprising the State highway system during the years 1972 to 1974 by parish.[12] The data, which will be referred to here as "State VMT", were categorized into urban and rural classifications by the following road types:

- Interstate
- State Primary
- State Secondary
- State Farm-to-Market

In terms of functional classifications, interstate miles of roadway are considered limited access highways, and State primary and secondary are considered major and minor arterials, respectively. The farm-to-market category includes all other highways in the State highway system.

VMT data on roads which are not part of the State highway system, which will be referred to as "local VMT", consist of miles of travel on non-State roads including freeways, arterials, collectors and city streets. The Louisiana Department of Highways provided estimates of VMT on local rural roads by parish for various years, ranging from 1969 to 1975. Adjustments were made to the base year using local rural VMT data from an earlier TRW study, Hydrocarbon Control Requirements for Southern Louisiana.[13] Estimates of local urban VMT for 1973 were also obtained from this study.

Once VMT data were compiled, they were projected to 1975, 1976, 1977, 1978, 1980 and 1985. State and local VMT were projected using growth factors based upon growth in VMT between 1972 and 1974 on the urban portion of the State highway system. Growth factors based upon the change in VMT on the urban portion of the State highway system and those based upon the change in total VMT on the State highway system did not differ significantly except for one case. In Lake Charles, total VMT in the analysis area declined during the 1972 to 1974 period which would yield a negative growth factor. This was not considered a very good indicator of growth to 1985, especially in light of population projections for the area. The decrease of total State VMT in the Lake Charles analysis area seems to be attributable to a decrease in rural State VMT since urban State VMT actually increased during the same period. The manner in which the statistics are compiled does not allow for more than conjecture as to how VMT is actually changing. Growth factors based upon changes in urban State VMT were assumed to be more representative of VMT growth taking place in the analysis areas.

Emission Factors - Emission factors for motor vehicles were calculated according to procedures specified in Supplement 5 of AP-42. Exhaust, evaporative and crankcase hydrocarbon emissions were estimated for light duty vehicles (LDV), light duty trucks

(LDT), heavy duty gasoline powered trucks (HDT-Gas) and heavy duty diesel powered trucks (HDT-Diesel).*

Vehicle registration data by model year were obtained from the Motor Statistical Division of the R. L. Polk Company. Average speed (38.99 mph) was calculated by weighting average speeds assumed for each road type by the percentage of total VMT traveled on each. The overall vehicle mix was assumed to be 90 percent light duty vehicles and 10 percent trucks. The national average weighted annual travel for heavy duty vehicles (including light duty trucks) was assumed. The vehicle mix for trucks alone was estimated for Louisiana using the nationwide vehicle mix; LDT = 60.20%, HDT-Gas = 23.47%, and HDT-Diesel = 16.33%.**

2.3.2 Off-Highway Fuel Use

Off-highway hydrocarbon emissions sources are categorized into outboard vessels and other off-highway sources.

Outboard Vessels--In order to estimate emissions from outboard vessels, motorboat registration data by parish were obtained from the Louisiana Wildlife and Fishery Commission[15] for the years 1970-1975. Procedures specified in AP-42 assuming the nationwide average values

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[*] On the basis of information from the California Air Resources Board, the methane content of motor vehicle exhaust was assumed to be 10 percent.[14] For lack of any better data, this same assumption was made for all IC engines.

[**] In other words, 10 percent of total VMT is attributable to trucks; of that 10 percent, 60.2 percent is due to LDT, 23.5 percent is due to HDT-Gas, and 16.3 percent is due to HDT-Diesel.

of horsepower output and annual hours of use were utilized. Future motorboat registrations were projected by extrapolating historical growth trends.

Other Off-Highway Sources--Hydrocarbon emissions generated by other off-highway engines were estimated from the amount of non-taxable gasoline sold by parish obtained for the years 1970-1975 from the Louisiana Department of Revenue.[16] Historical growth trends were extrapolated to project future sales and the emission factor from the National Emissions Data System (NEDS) area source program was applied.

2.3.3 Aircraft

Total hydrocarbon emissions resulting from aircraft operations are estimated as a function of landing and take-off (LTO) cycles, and fleet mix. Procedures given in reference 5 were followed. The number of LTO cycles recorded at Federal Aviation Administration (FAA) controlled airports in 1974 in each analysis area were obtained from the FAA publication Air Traffic Activity 1974.[17] LTO cycles at non-FAA controlled airports were estimated by assuming that the total number of eligible aircraft in each parish was approximately equal to the number of daily LTO cycles performed by Civil Aircraft. The number of eligible aircraft was available from the Census of U. S. Civil Aircraft.[18] There are no military airports located within the defined study areas.

The 1975 air fleet mix and emission factors were obtained from a previous TRW study.[13] Growth factors for projecting future LTO cycles were obtained from Aviation Forecast--Fiscal Years 1970-1981.[19]

2.3.4 Railroads

Total hydrocarbon emissions resulting from railroad fuel combustion were calculated based on fuel use data available from the Bureau of Mines,[20] and AP-42 average locomotive emission factors. Nineteen seventy-four (1974) fuel use data for the State of Louisiana were allocated to the three analysis areas according to manufacturing employment, which was assumed to be an indicator of the distribution of railroad activities throughout the state. An estimation of the total miles of track within each analysis area yielded a comparable distribution.* Estimates of 1975 and future emissions were calculated using growth factors based upon projections of future earnings in the railroad transportation industry obtained from the 1972 OBERS Projections.[21]

2.3.5 Vessels

Data on the number of vessels entering the ports of New Orleans and Baton Rouge were obtained from Waterborne Commerce of the United States.[9] Fuel consumption data were obtained from the Bureau of Mines.[20] Procedures presented in the NEDS guide[5] were followed, using these data and AP-42 emission factors. Briefly, estimating in-port emissions entailed estimating the amount of residual and distillate fuel oil burned while a vessel was in port and applying the appropriate emission factor. Once the in-port use of distillate fuel oil was calculated, it was subtracted from the total distillate fuel oil used by vessels to estimate fuel burned underway. It was assumed that the majority of vessels underway would be burning distillate fuel oil. Underway emissions were allocated to each port on the basis of the amount of freight handled. Average annual growth factors based upon historical growth in freight traffic between 1965 and 1974 were used to project future port activity.

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*Miles of track = 47.2% of state total; manufacturing employment = 46.6% of state total.

2.3.6 Gasoline Evaporation

Evaporative losses from the handling of gasoline were estimated for three operations: the loading and unloading of tank cars and trucks (assuming submerged loading), the loading of underground storage tanks (assuming uncontrolled submerged loading), and the filling of motor vehicle tanks (assumed to be uncontrolled). Data on the amount of gasoline sold in each analysis area were obtained from the Louisiana Department of Revenue for the years 1970 to 1975.[16] EPA emission factors were employed and historical growth trends in sales were extrapolated to project future gasoline marketing activities.

3.0 DISCUSSION OF RESULTS

3.1 EMISSIONS SUMMARIES

The emissions inventories are given in Tables 4a and 4b, for Baton Rouge; Tables 5a and 5b for Lake Charles; and Tables 6a and 6b for New Orleans. In all of the analysis areas, point sources are by far the major emissions sources, unlike many areas where transportation sources are the most prominent sources. The petroleum refining and chemical manufacturing categories are the principal emitters.

3.2 RECOMMENDATIONS

On the basis of the emissions analysis and the results from the other subtasks comprising the overall study, the following control measures were recommended for further study and possible implementation in AQCR 106, in order to meet the NAAQS for photochemical oxidants:

1. A tightening of the variance procedures and the exemptions for certain organic materials in the Louisiana Hydrocarbon Regulations.
2. Controls on ship and barge loading of organic materials.
3. Controls on retail gasoline tank filling operations.

The State is currently incorporating items 1 and 3 into the regulations. Based on the use of the modified rollback model, these revisions should bring all three analysis areas into essential compliance with the national oxidant standard.

TABLE 4a

TOTAL HYDROCARBON EMISSIONS - BATON ROUGE ANALYSIS AREA[a]

	SOURCE CATEGORY	1975	1976	1977	1978	1980	1985
I.	Stationary Area Sources						
	A. Drycleaning/Solvents	1,178	1,199	1,222	1,246	1,297	1,456
	B. Fuel Combustion	82	83	85	86	87	95
	C. Total Area Sources	1,260	1,282	1,307	1,332	1,384	1,551
II.	Point Sources						
	A. Chemical/Manufacturing	53,910	47,600	46,061	48,461	53,763	69,703
	B. Electricity Generation	709	786	865	945	1,056	1,456
	C. Petroleum Refining	25,289	30,867	30,867	30,867	35,835	35,835
	D. Ship & Barge Loading	5,305	5,426	5,550	5,677	5,942	6,661
	E. Total Point Sources	85,213	84,679	83,343	85,950	96,596	113,655
III.	Transportation Sources						
	A. Motor Vehicles-Total	18,735	17,539	17,328	16,677	14,403	9,598
	1. Automobiles	15,804	14,612	14,411	13,721	11,728	7,297
	2. Trucks	2,931	2,927	2,917	2,956	2,675	2,301
	B. Off-Highway Fuel	1,532	1,643	1,770	1,911	2,245	3,494
	C. Aircraft	241	261	275	285	301	371
	D. Railroads	729	724	719	714	704	680
	E. Vessels	1,271	1,364	1,464	1,571	1,808	2,573
	F. Gasoline Handling	2,784	2,923	3,070	3,230	3,563	4,538
	G. Total Transportation	25,292	24,454	24,626	24,388	23,024	21,254
IV.	Grand Total	111,765	110,415	109,276	111,670	121,004	136,460.
	% Stationary Area Sources	1.1	1.2	1.2	1.2	1.1	1.1
	% Point Sources	76.3	76.7	76.3	77.0	79.9	83.3
	% Transportation	22.6	22.1	22.5	21.8	19.0	15.6
	(% Automobiles)	(14.1)	(13.2)	(13.2)	(12.3)	(9.7)	(5.3)
	Required Reduction	60,353	-	-	-	-	-
	Allowable Emissions	51,412	51,412	51,412	51,412	51,412	51,412
	Emissions Deficit	60,353	59,003	57,864	60,258	69,592	85,048

[a] Tons per year.

TABLE 4b

NON-METHANE HYDROCARBON EMISSIONS - BATON ROUGE ANALYSIS AREA[a]

SOURCE CATEGORY	1975	1976	1977	1978	1980	1985
I. Stationary Area Sources						
A. Drycleaning/Solvents	1,178	1,199	1,222	1,246	1,297	1,456
B. Fuel Combustion	0	0	0	0	0	0
C. Total Area Sources	1,178	1,199	1,222	1,246	1,297	1,456
II. Point Sources						
A. Chemical/Manufacturing	46,988	40,662	38,912	40,931	45,409	58,873
B. Electricity Generation	0	0	0	0	0	0
C. Petroleum Refining	24,176	29,503	29,503	29,503	34,247	34,247
D. Ship & Barge Loading	5,305	5,426	5,550	5,677	5,942	6,661
E. Total Point Sources	76,469	75,591	73,965	76,111	85,598	99,781
III. Transportation Sources						
A. Motor Vehicles-Total	16,861	15,785	15,595	15,009	12,963	8,638
1. Automobiles	14,223	13,151	12,970	12,349	10,555	6,567
2. Trucks	2,638	2,634	2,625	2,660	2,408	2,071
B. Off-Highway Fuel	1,379	1,479	1,593	1,720	2,021	3,145
C. Aircraft	217	235	247	257	271	334
D. Railroads	656	652	647	643	634	612
E. Vessels	1,144	1,228	1,318	1,414	1,627	2,316
F. Gasoline Handling	2,784	2,923	3,070	3,230	3,563	4,538
G. Total Transportation	23,041	22,302	22,470	22,273	21,079	19,583
IV. Grand Total	100,688	99,092	97,657	99,630	107,974	120,820
% Stationary Area Sources	1.2	1.2	1.3	1.3	1.2	1.2
% Point Sources	75.9	76.3	75.7	76.4	79.3	82.6
% Transportation Sources	22.9	22.5	23.0	22.3	19.5	16.2
(% Automobiles)	(14.1)	(13.3)	(13.3)	(12.4)	(9.8)	(5.4)
Required Reduction	54,372	-	-	-	-	-
Allowable Emissions	46,316	46,316	46,316	46,316	46,316	46,316
Emissions Deficit	54,372	52,776	51,341	53,314	61,658	74,504

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[a] Tons per year.

TABLE 5a

TOTAL HYDROCARBON EMISSIONS - LAKE CHARLES ANALYSIS AREA[a]

	SOURCE CATEGORY	1975	1976	1977	1978	1980	1985
I.	Stationary Area Sources						
	A. Drycleaning/Solvents	409	415	423	431	448	500
	B. Fuel Combustion	26	26	26	27	27	28
	C. Total Area Sources	435	441	449	458	475	528
II.	Point Sources						
	A. Chemical/Manufacturing	25,441	20,227	17,441	15,440	17,023	21,726
	B. Electricity Generation	254	267	280	293	316	380
	C. Petroleum Refining	22,129	21,797	21,797	22,405	23,674	27,166
	D. Ship and Barge Loading	499	513	528	542	574	660
	E. Total Point Sources	48,323	42,804	40,046	38,680	41,588	49,932
III.	Transportation Sources						
	A. Motor Vehicles-Total	8,049	7,803	7,989	7,969	7,129	5,878
	1. Automobiles	6,790	6,501	6,644	6,557	5,805	4,469
	2. Trucks	1,259	1,302	1,345	1,412	1,324	1,409
	B. Off-Highway Fuel	599	652	710	775	924	1,471
	C. Aircraft	141	152	160	166	176	216
	D. Railroads	350	345	340	335	325	301
	E. Vessels	0	0	0	0	0	0
	F. Gasoline Handling	1,009	1,070	1,134	1,201	1,362	1,807
	G. Total Transportation	10,148	10,022	10,333	10,446	9,916	9,673
IV.	Grand Total	58,906	53,267	50,828	49,584	51,979	60,133
	% Stationary Area Sources	0.7	0.8	0.9	0.9	0.9	0.9
	% Point Sources	82.1	80.4	78.8	78.0	80.0	83.0
	% Transportation Sources	17.2	18.8	20.3	21.1	19.1	16.1
	(% Automobiles)	(11.5)	(12.2)	(13.1)	(13.2)	(11.2)	(7.4)
	Required Reduction	32,398	-	-	-	-	-
	Allowable Emissions	26,508	26,508	26,508	26,508	26,508	26,508
	Emissions Deficit	32,398	26,759	24,320	23,076	25,471	33,625

[a] Tons per year.

TABLE 5b

NON-METHANE HYDROCARBON EMISSIONS - LAKE CHARLES ANALYSIS AREA[a]

	SOURCE CATEGORY	1975	1976	1977	1978	1980	1985
I.	Stationary Area Sources						
	A. Drycleaning/Solvents	409	415	423	431	448	500
	B. Fuel Combustion	0	0	0	0	0	0
	C. Total Area Sources	409	415	423	431	448	500
II.	Point Sources						
	A. Chemical/Manufacturing	23,357	18,061	16,020	14,019	15,456	19,726
	B. Electricity Generation	0	0	0	0	0	0
	C. Petroleum Refining	20,996	20,664	20,664	21,241	22,443	25,754
	D. Ship & Barge Loading	499	513	528	542	574	660
	E. Total Point Sources	44,852	39,238	37,212	35,802	38,473	46,140
III.	Transportation Sources						
	A. Motor Vehicles-Total	7,244	7,023	7,190	7,172	6,416	5,290
	1. Automobiles	6,111	5,851	5,980	5,901	5,224	4,022
	2. Trucks	1,133	1,172	1,210	1,271	1,192	1,268
	B. Off-Highway Fuel	539	587	639	697	832	1,324
	C. Aircraft	127	137	144	149	158	194
	D. Railroads	315	311	306	301	293	271
	E. Vessels	0	0	0	0	0	0
	F. Gasoline Handling	1,009	1,070	1,134	1,201	1,362	1,807
	G. Total Transportation	9,234	9,128	9,413	9,520	9,061	8,886
IV.	Grand Total	54,495	48,781	47,048	45,753	47,982	55,526
	% Stationary Area Sources	0.8	0.9	0.9	0.9	0.9	0.9
	% Point Sources	82.3	80.4	79.1	78.3	80.2	83.1
	% Transportation	16.9	18.7	20.0	20.8	18.9	16.0
	(% Automobiles)	(11.2)	(12.0)	(12.7)	(12.9)	(10.9)	(7.2)
	Required Reduction	29,972	-	-	-	-	-
	Allowable Emissions	24,523	24,523	24,523	24,523	24,523	24,523
	Emissions Deficit	29,972	24,258	22,525	21,230	23,459	31,003

[a] Tons per year.

TABLE 6a

TOTAL HYDROCARBON EMISSIONS - NEW ORLEANS ANALYSIS AREA[a]

	SOURCE CATEGORY	1975	1976	1977	1978	1980	1985
I.	Stationary Area Sources						
	A. Drycleaning/Solvents	3,149	3,203	3,259	3,319	3,449	3,844
	B. Fuel Combustion	237	240	242	245	251	267
	C. Total Area Sources	3,386	3,443	3,501	3,564	3,700	4,111
II.	Point Sources						
	A. Chemical/Manufacturing	42,740	28,536	29,070	30,619	33,969	44,041
	B. Electricity Generation	1,092	1,176	1,263	1,355	1,527	2,046
	C. Petroleum Refining	32,076	28,766	29,866	30,514	31,852	35,463
	D. Ship & Barge Loading	9,876	10,096	10,319	10,548	11,022	12,305
	E. Total Point Sources	85,784	68,574	70,518	73,036	78,370	93,855
III.	Transportation Sources						
	A. Motor Vehicles-Total	24,911	22,831	22,084	20,811	18,161	10,337
	1. Automobiles	21,013	19,021	18,367	17,123	14,788	7,859
	2. Trucks	3,898	3,810	3,717	3,688	3,373	2,478
	B. Off-Highway Fuel	2,812	2,852	2,904	2,967	3,129	3,735
	C. Aircraft	1,628	1,760	1,853	1,923	2,032	2,503
	D. Railroads	1,836	1,820	1,803	1,786	1,755	1,677
	E. Vessels	3,973	4,195	4,430	4,678	5,217	6,851
	F. Gasoline Handling	4,876	5,119	5,478	5,656	6,241	7,947
	G. Total Transportation	40,036	38,577	38,552	37,821	36,535	33,050
IV.	Grand Total	129,206	110,594	112,571	114,421	118,605	131,016
	% Stationary Area Sources	2.6	3.1	3.1	3.1	3.1	3.1
	% Point Sources	66.4	62.0	62.7	63.8	66.1	71.7
	% Transportation Sources	31.0	34.9	34.2	33.1	30.8	25.2
	(% Automobiles)	(16.3)	(17.2)	(16.3)	(15.0)	(12.5)	(6.0)
	Required Reduction	19,381	-	-	-	-	-
	Allowable Emissions	109,825	109,825	109,825	109,825	109,825	109,825
	Emissions Deficit	19,381	769	2,746	4,596	8,780	21,191

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[a] Tons per year.

TABLE 6b

NON-METHANE HYDROCARBON EMISSIONS - NEW ORLEANS ANALYSIS AREA[a]

	SOURCE CATEGORY	1975	1976	1977	1978	1980	1985
I.	Stationary Area Sources						
	A. Drycleaning/Solvents	3,149	3,203	3,259	3,319	3,449	3,844
	B. Fuel Combustion	0	0	0	0	0	0
	C. Total Area Sources	3,149	3,203	3,259	3.319	3,449	3,844
II.	Point Sources						
	A. Chemical/Manufacturing	39,953	25,724	26,106	27,497	30,505	39,550
	B. Electricity Generation	0	0	0	0	0	0
	C. Petroleum Refining	30,508	27,198	28,248	28,861	30,126	33,542
	D. Ship & Barge Loading	9,876	10,096	10,319	10,548	11,022	12,305
	E. Total Point Sources	80,337	63,018	64,673	66,906	71,653	85,397
III.	Transportation Sources						
	A. Motor Vehicles-Total	22,420	20,548	19,876	18,730	16,345	9,303
	1. Automobiles	18,912	17,119	16,530	15,411	13,309	7,073
	2. Trucks	3,508	3,429	3,346	3,319	3,036	2,230
	B. Off-Highway Fuel	2,531	2,567	2,614	2,670	2,816	3,361
	C. Aircraft	1,465	1,584	1,668	1,731	1,829	2,253
	D. Railroads	1,652	1,638	1,623	1,607	1,579	1,509
	E. Vessels	3,576	3,775	3,987	4,210	4,695	6,166
	F. Gasoline Handling	4,876	5,119	5,478	5,656	6,241	7,947
	G. Total Transportation	36,520	35,231	35,246	34,604	33,505	30,539
IV.	Grand Total	120,006	101,452	103,178	104,829	108,607	119,780
	% Stationary Area Sources	2.6	3.2	3.2	3.2	3.2	3.2
	% Point Sources	67.0	62.1	62.6	63.8	66.0	71.3
	% Transportation Sources	30.4	34.7	34.2	33.0	30.8	25.5
	(% Automobiles)	(15.8)	(16.9)	(16.0)	(14.7)	(12.3)	(5.9)
	Required Reduction	18,001	-	-	-	-	-
	Allowable Emissions	102,005	102,005	102,005	102,005	102,005	102,005
	Emissions Deficit	18,001	-553	1,173	2,824	6,602	17,775

[a] Tons per year.

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CONDENSED DISCUSSION

Question: You said you did a total hydrocarbon and a nonmethane hydrocarbon inventory. Where did you get the factors for nonmethane hydrocarbons? Most of the factors in AP-42 are for total hydrocarbon.

Piske: For the point sources, they came out from the emission inventory questionnaires. Various sources were used for other data needed.

Question: What did you do with the sources for which there were no emission factors in AP-42? Did you go back and try to collect more specific information process information or use some other approach? What generally happens if there is no emission factor?

Piske: Well, if you are talking about specific point sources or process, we worked with the State who went right to the point source and tried to get the information the best we could. Some of them had to be estimates, for some companies just don't have the information.

Question to Moderator How do you determine an emission factor starting from scratch?

CONDENSED DISCUSSION

Moderator: It varies completely across the board. As you are probably aware, there is great difference in quality of various existing emission factors. I guess you would call it a difference, not necessarily in reliability, but in the reference integrity or depth for these factors. The emission factors range from a few example situations where a recognized expert in a given area or industry may have utilized his best engineering judgement based on past experiences and material balance information to provide a general estimate or rule of thumb, such as "approximately 1/2% loss" or something of that nature. On the other end of the spectrum, we have other emission factors which literally have hundreds of test points which are used with exhaustive statistical analysis. Usually, though, it's difficult to apply rigid statistical approaches to the development of emission factors because there is usually some "quirk" in the data someplace. You have to develop an understanding that particular industry and some of these characteristics or quirks, and subsequently try to apply best engineering judgement possible.

CONDENSED DISCUSSION

Question: What are the requirements now regarding what models to use for oxidant strategy development?

Ed Lillis: Your question is with respect to what model or what method you can use to relate emissions and air quality. Over the past year and a half or so, we have been attempting to develop a replacement for Appendix J. Appendix J was promulgated as a technique which was specified in State Implementation Plan regulations. As new methods are developed and used, we will be better able to relate emissions and reduction in organic emissions to ambient oxidant concentrations. By using such a model, you are able to say that if I have a present oxidant concentration, and if I reduce my organic emissions so much, I would get a quantifiable improvement in air quality. About two years ago, the Appendix J method was criticized for a number of different reasons and since that time there has been a working group at EPA attempting to look at other methodologies for relating emissions to oxidant concentrations. At the present time a document is being prepared

CONDENSED DISCUSSION

Ed Lillis: (con't) which discusses the advantages and disadvantages of each of four methods. There are the Appendix J and the linear roll back methodologies, statistical techniques, atmospheric difussion modeling and a fifth method called the Empirical Kinetic Modeling Approach, which is a new technique that has been developed on the basis of smog chamber data. At the present time the agency is not recommending or requiring the use of one technique over another technique. The document that is being prepared has fully described each of these five techniques, the advantages and disadvantages of each and neither makes decisions nor recommendations for using one model versus another one.

Question: So it is up to the States?

Ed Lillis: At the present time. In order to implement the Clean Air Act, there may be a decision made within the next few months, which would say to use one versus another or that you may not use one or another of these methods.

Question: In making your recommendation of ship and barge loading, do you take into consideration not only

CONDENSED DISCUSSION

Question: (con't)	the emission inventory, but also the direction in which the hydrocarbon is going, in other words, the wind direction?
Piske:	No, we didn't make any account for meteorology in this particular study at all. This was done utilizing linear roll back which basically says all the ambient values are proportional to your total emissions in a given area. That's all we did, we didn't consider any meteorology.

DOCUMENTATION OF EMISSION INVENTORIES IN REGION IX

Presented at the 1977
Environmental Protection Agency
Emission Inventory/Factor Workshop
Raleigh, North Carolina - September 13-15, 1977

By

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Documentation of Emission Inventories

In the past, emission inventories generally have not been used by regulatory agencies for control program planning. Instead, they were primarily used by the control agencies for public relations purposes. Thus, little effort was put into developing accurate and complete emission inventories and the task of compiling the inventories were assigned to the junior staff members. While recently emission inventories have been an important tool in developing SIPs, an accurate emission inventory has acquired added importance as a result of the New Source Review and Air Quality Maintenance Planning Programs.

In addition, the 1977 amendments to the Clean Air Act require an SIP submission by January, 1979 and one of the criteria specified in the act for an acceptable SIP, is "an accurate comprehensive and current emission inventory."

In order to insure that the emission inventories currently being developed are prepared using the most current emission factors and have a completely documented data base, Region IX has instituted a program for providing inventory guidance to the State and local agencies and for evaluating the accuracy and completeness of the inventories developed by the agencies.

During the past year eight State or local agency emission inventories were evaluated by Region IX. Since several of the initial inventories submitted to the Regional Office were a summary of the emissions rather than a complete and documented inventory report, it was necessary to interview the appropriate staff at the air pollution control agencies in order to determine the accuracy and completeness of the inventories.

The review of inventories indicated that most of the procedures used in compiling the inventories were not sufficiently documented to provide for an independent analysis of the inventory. As a result of these evaluations, the Regional Office developed the minimum criteria for documenting the data base of an inventory. The guideline was subsequently incorporated as an appendix to an emission inventory objective that is a part of the EPA 105 program grant allocated to the local and State agencies. A copy of the Supporting Documentation Guideline is attached. The intent of the guideline is to insure that the agency compiling an inventory in the future, will be aware of what information must be collected to support the accuracy and completeness of the inventory.

The interviews that were initiated to evaluate the inventories were conducted over a one or two day period in the office of the air pollution control agency. Also many additional followup telephone calls were necessary to obtain the needed information.

Discussions with agencies personnel revealed that most of the emission inventories had been developed as a "crash effort" to meet a deadline.

Temporary employees were hired and placed under the supervision of a senior staff member. Generally, the temporary employees were college students with a background in the physical sciences but no experience in air pollution control. As a result, errors were found in the inventories which were the result of a lack of experience by the temporary employees. For example, in one inventory it was found that the same emission factors were used for gasoline service stations as was used for bulk plants. The temporary employees did not know there was a difference between bulk plants and service stations. Unfortunately, the temporary employees were not available when it became necessary to locate them to obtain information on how the inventories were developed.

The guidelines recommend that the documentation include information on the reasons the inventory was compiled and how it differed from previous inventories. During the review of one of the inventories, in one case it was found that the air pollution control agency had traditionally compiled its emission inventory by assigning each source category to a senior engineer. One person would be responsible for maintaining an estimate of emissions from all industrial boilers while another person would be responsible for inventorying emissions from chemical processes. It was found that the persons preparing these yearly emission updates were not contacting each source to obtain process change information but would apply a correction factor to last years estimate. There was no consistency among the correction factors applied by the staff. A past years emission estimate would arbitrarily be reduced by 5% since the opinion of the individual making the estimate was that there was a general economic downturn last year of this magnitude. The origins of the original estimates were unknown to many of the persons making the yearly corrections, having been in use for up to twenty years.

The background information on the purpose for compiling the inventory will often give an indication as to which sources the agency concentrated its efforts.

Sources of data should be described. These would include: permit applications, inspection reports, source tests, questionnaires, and permits. In one inventory it was found that the estimates were derived from the permit applications in which the companies estimated their own emissions. An oil refinery which listed its hydrocarbon emissions as 3 tons/year on its permit application was found to have emissions of 150 tons/year when the agency personnel made their own estimates.

A copy of each questionnaire which was used in the inventory is required to be included in the documentation for two reasons:

1. So that a determination can be made as to whether sufficient information is being collected on the survey for the agency to accurately estimate emissions.

2. So that copies of all questionnaires are made available to other agencies to assist them in preparing their own questionnaires.

The agency must also present the number of questionnaires that were sent out, the percent response, and the method used to extrapolate the data. It is not unusual for an agency to only receive a 35% response to the questionnaires and then assume that the other 65% not responding either had no emissions or emissions proportional to the 35% who did respond.

Emission factors used for each source category calculation should be presented for each emission factor used. In the cases where there was no documentation, it was necessary in some instances to determine the emission factor by back calculating. In some cases, it is still not known how the emission factor was derived.

Although the calculation procedures contained in AP-42 appear to be straight-forward they are frequently mis-used. Some examples of the incorrect use of emission factors include:

a. Breathing loss emission factors are multiplied times the storage tanks throughput rather than its capacity.

b. Withdrawal losses are not included in the calculation of floating roof storage tank losses.

c. The estimates can be off by a factor of 42, 365, or 12 due to the person compiling the inventory neglecting to include in the calcualtion a conversion for 42 gal/bbl, 365 days/year, or 12 months/year.

d. Anticipating that additional controls will be applied by a certain date. When the controls are not applied by the expected date, the agency neglects to amend the inventory.

e. Assuming that all storage tanks have Phase I vapor control equipment. Actually only tanks over 2,000 gallons capacity were required to have Phase I controls.

f. Applying refinery fugitive emission factors to oil field operations.

g. Using the agricultural tilling emission factors as though they were annual average estimates. When actually the emission factors must be multiplied times the number of times the acreage is tilled per year.

A comparison is normally made of each listed emission factor against the current AP-42. In one case it was found that an agency was still using Supplements 1-4 of AP-42, believing these were current. Copies of Supplements 5, 6, 7, & 8 had been sent to the agency but were received by another person who neatly stacked them in his book case. Old AP-42 supplements should not be discarded as they can be useful in identifying the origin of obsolete emission factors.

All categories listed in the required format must be completed. There can only be blanks in the inventory when it is clearly stated that the category was not inventoried. If the category was inventoried and found to have no emissions then a "0" is entered. If emissions were found to be negligible then "neg" is entered.

The documentation should be in sufficient detail so that every assumption is described explicitly. Examples of assumptions which were found to be inaccurately included in emission inventories are:

1. Assuming that all boats launched in a recreational lake are motor boats when actually 1/2 are sail boats.

2. Assuming that only 3 axle trucks are heavy duty, when actually many 2 axle trucks are heavy duty.

3. Assuming that all the fuel transferred by a railroad in the county was consumed in the county. The county turned out to be the major refueling depot for the railroads entire west coast operations.

The emission inventory reporsents the agencies best effort given the information and resources available to it at the time. The amount of new information on emission factors currently being developed by EPA, the States, and private industry is overwhelming. One air pollution control agency within California is currently performing 200 to 300 source tests per year and generates its own emission factors from this data. Examples of on-going efforts to develop improved emission factors are:

1. A.P.I. studies to develop new correlations for fixed and floating roof emission factors.

2. The State of California programs to develop emission factors for steam stimulated crude oil production and pesticide emissions.

3. The State of Arizona's and Pima County's projects to develop localized fugitive dust emission factors.

4. EPA's study to update cotton ginning emission factors.

5. A.P.I.'s current study on fugitive emissions from onshore and offshore oil production.

An area of emission estimates which we have found lacking in current data is hydrocarbon speciation. In order to apply the hydrocarbon emission estimates to atmospheric diffusion models it is not only necessary to know the total hydrocarbon but the percentage of each hydrocarbon species. Very little recent work has been done on determination of hydrocarbon species identification from mobile, stationary, and area sources of hydrocarbon species is the amount of methane present in external combustion devices' exhaust. At the present time EPA and the California ARB are assuming that 45% of the exhaust gas is methane, regardless if the external combustion device is gas or oil fired. EPA's Industrial

Environmental Research Laboratory was contacted and a staff member advised that no work had been done on identifying the percent methane, but his personal estimate was that the exhaust gas from a gas fired external combustion device would be 90% methane. Similar examples can be cited for most other emission source categories.

Supporting Documentation

Sufficient documentation is required to support the accuracy of the inventory and to allow for a complete analysis of the inventory.

A. Background information on reasons for the inventory being compiled, its future use, how it evolved and significant changes from the emissions of previous years should be presented.

B. The geographic area covered by the inventory should be specified. This may be the County, the air basin or the AQMA.

C. The Emission Inventory should be presented in a table format. The required format is included as Appendix C.

1. All source categories listed in the sample format should be included in the Emission Inventory.
2. Source categories for which the emissions are negligible should be listed as "Neg."
3. Source categories for which there are not emissions in the County should be listed as "0."

D. A narrative must also be presented for each category of the inventory. The narrative must contain at least the following:

1. Procedures used to collect the data - Complete procedures should be presented which describe how the data was collected and analyzed.

2. Sources of the data - A complete description of the types of sources accessed in the course of compiling the inventory should be presented. These sources would include for example, permit files, inspection reports, source test data, actual company inquiries, Departments if Agriculture of Highways, local fire departments, etc. A statement should be included assessing the completeness of the data collected.

3. Copies of questionnaires - Sample copies of questionnaires mailed to various sources for the collection of data should be included as part of the inventory document.

4. Questionnaire statistics - Statistics regarding the questionnaires or other letters of inquiry sould be presented. This information shall include:

a. the number of questionnaires sent
b. the number for which response was received
c. the method of extrapolating available information for non-respondants
d. any assumptions made regarding the data received or not received.

5. Emission factor citation - Emission factors used for the calculation of emissions should be clearly stated. Factors other than AP-42 may be utilized, however, a one-sentence rationale for the use of non-AP-42 factors is required. Source test data should be used in preference over emission factors.

6. Method of calculation - Sample calculations for each type of computation should be presented. The purpose of this is to allow for an independent varification of the computations. (Petroleum handling factors are frequently misused.)

7. Assumptions - Any assumptions made in any part of the procedures should be clearly stated.

8. Items not included - Any source of emissions which contributes to air quality of the County being inventoried but which were not included in the inventory should be itemized in the narrative. A statement as to why these sources were not included should be presented. Possible reasons for non-inclusion include:

   a. The emissions from these sources are negligible.

   b. No emission factors exist and no source test data is available to allow computation of these emissions.

9. A list of references should be included as a final section of the narrative.

CONDENSED DISCUSSION

Question: A few years back we heard something about aircraft dumping fuel prior to landing. What's happened to that? I haven't seen much in the news like that lately?

Henderson: I understand that the commercial aircraft don't do it and we haven't been able to get any information from the military on it.

METHODOLOGIES AND PROBLEMS ENCOUNTERED IN A LEVEL 3 MULTI-STATE/COUNTY HYDROCARBON AREA SOURCE EMISSIONS INVENTORY

Presented at the 1977
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ABSTRACT

This paper is directed to the assessment of methodologies and major problems encountered in multi-state/county Level 3 hydrocarbon area source emissions inventories. Time constraints and cost considerations do not easily allow Level 3 efforts to be fulfilled as shown in the case study discussed in this paper

The study discussed encompassed 47 counties in seven states and two EPA regions. Area source categories included in the study consisted of residential fuel, commercial and institutional fuel, industrial fuel, onsite incineration, open burning, off-highway gasoline fuel, off-highway and rail locomotive diesel fuel, aircraft, vessels, and evaporation sources. Methodologies employed to these categories consisted of a mixture of the three levels of analysis and various other techniques developed subject to specific parameters such as state and local air pollution control agency participation, funding, availability and timeliness of the receipt of requested data, and the availability of time to complete the study.

Problems encountered in the study which are discussed in this paper include (1) planning considerations, as related to area source publications, cost and time factors; (2) surveying methodology problems such as composite source list development, questionnaire printing, and drycleaning solvent supplier inventory; (3) railroad methodology; and (4) agency participation.

SECTION I

INTRODUCTION

The U.S. Environmental Protection Agency (EPA) is responsible for ensuring the attainment and maintenance of National Ambient Air Quality Standards (NAAQS) for photochemical oxidants. The control strategies that must be developed to meet these standards involve gathering information on hydrocarbon emissions, through an emissions inventory, from point and area sources. Large sources of air pollution are considered point sources and are usually well surveyed and documented by means of air pollution permit programs and field investigations. Emissions from sources too small or too difficult to be surveyed individually are reported collectively as area sources. Each small source may emit only a minimal amount of air pollutants, but, because of the vast number of these small sources, their collective impact can be significant.

To determine emissions attributed to hydrocarbon area sources, the Air Programs Branch of EPA, Region V, contracted Pacific Environmental Services, Inc. (PES) to develop an extensive and comprehensive Level 3 nonhighway hydrocarbon area source emissions inventory. This inventory will be used in making subsequent revisions to State Implementation Plans (SIPs) allowable oxidant levels.

The intent of this paper is to provide the reader with an understanding of some of the problems encountered in applying Level 3 analysis to a multi-state/county emissions inventory. Level 3 is defined [in EPA document Guidelines for Air Quality Maintenance and Analysis. Volume 7: Projecting County Emissions, OAQPS No. 1.2-026]

(Guidelines) as a method which provides the highest degree of accuracy in an inventory and relies on extensive contact or interviewing with organizations responsible for the major pollution sources to determine emissions. Although Level 3 inventories usually provide excellent quality data, the methodology guidelines set forth in various governmental publications are not oriented toward large-scale studies, providing for some unique problems.

This paper is organized into seven sections, including this introduction. Section II provides a brief description of the subject inventory and all parameters associated with it. Sections III through VI provide insight into four types of problems encountered in this project, and PES's approach to solving them. It should be noted that in a paper of this nature, all of the problems and methodologies employed cannot be discussed in any great detail, but an attempt has been made to familiarize the reader with them. The last section summarizes the study and provides conclusions.

SECTION II

PROJECT DESCRIPTION

The intent of the ongoing PES project is to furnish EPA with a comprehensive nonhighway area source emissions inventory for hydrocarbons with a base year of 1975. Area sources, as defined by the Scope of Work for this project, are those sources which have the potential to emit less than 25 tons of hydrocarbons per year. Hydrocarbons, for the purposes of this inventory, are defined as total hydrocarbons (methane and nonmethane). The geographical study area encompasses 47 counties in seven states and EPA Regions IV and V. The study area includes most of the major metropolitan areas of Region V and accounts for a total population of approximately 23,269,500. Table 1 presents the states, counties, metropolitan areas, and population of each county contained in the study.

National Emissions Data System (NEDS) hydrocarbon area source categories contained in the project, as outlined in 40CFR Part 51, Appendix D, include: residential fuel, commercial and institutional fuel, industrial fuel, onsite incineration, open burning, off-highway gasoline fuel, off-highway and rail locomotive diesel fuel, aircraft, vessels, and evaporative sources. Hydrocarbon emissions from these sources are being quantified into NEDS area source input format by the specific NEDS category in each of the 47 counties. Also, PES is reporting hydrocarbon emissions and solvent consumption for each of the various evaporative hydrocarbon Standard Industrial Classifications (SIC). Evaporative hydrocarbon SIC numbers being inventoried in the project are presented in Table 2.

Table 1. GEOGRAPHICAL DISTRIBUTION OF STUDY AREA

State	EPA Region	County	Population (est 1975)	Metropolitan Areas
Illinois	V	Cook	5,365,400	Chicago
		DuPage	542,500	
		Kane	266,800	
		Lake	396,800	
		McHenry	124,300	
		Will	287,100	
Indiana	V	Boone	32,300	Hammond-Gary Indianapolis
		Hamilton	68,300	
		Hancock	40,000	
		Hendricks	61,000	
		Johnson	70,100	
		Lake	544,600	
		Madison	138,100	
		Marion	789,000	
		Morgan	47,900	
		Porter	95,800	
		Shelby	38,800	
Kentucky	IV	Boone	37,100	Cincinnati
		Campbell	85,000	
		Kenton	130,500	
Michigan	V	Macomb	669,600	Detroit-Dearborn
		Monroe	126,500	
		Oakland	967,500	
		Wayne	2,536,700	
Minnesota	V	Anoka	185,400	Minneapolis-St. Paul
		Carver	34,000	
		Dakota	174,300	
		Hennepin	925,800	
		Ramsey	457,500	
		Scott	40,000	
		Washington	102,700	

Table 1. GEOGRAPHICAL DISTRIBUTION OF STUDY AREA (CONCLUDED)

State	EPA Region	County	Population (est 1975)	Metropolitan Areas
Ohio	V	Butler	244,100	Toledo
		Clermont	108,000	Cleveland
		Cuyahoga	1,603,900	Akron-Canton
		Franklin	866,100	Columbus
		Hamilton	905,000	Cincinnati
		Lake	205,600	Dayton
		Lucas	479,900	
		Mahoning	307,100	
		Montgomery	588,000	
		Stark	384,200	
		Summit	535,300	
		Trumbull	241,200	
		Warren	87,700	
Wisconsin	V	Kenosha	123,100	Milwaukee-Racine-Kenosha
		Milwaukee	1,032,900	
		Racine	175,900	

Table 2. PES AREA SOURCE HYDROCARBON EVAPORATIVE EMISSIONS CATEGORIES

SIC Number
2085
2231, 2261, 2262, 2269, 2295, 2297
2435, 2492
2511, 2514, 2521, 2542
2641, 2643, 2645, 2651, 2653
2711, 2732, 2751, 2752, 2753
2821, 2823, 2842, 2851, 2861, 2895, 2983
2900
3021, 3041, 3069
3111, 3149, 3161, 3172
3221
3357, 3398
3423, 3429, 3451, 3452, 3469, 3471, 3479
3537, 3551
3643, 3674
3711, 3713, 3714, 3715, 3732
3825, 3832
3914, 3915, 3944, 3951, 3953, 3955
5171
5982, 5983, 5984
7535

Although the project strived to utilize Level 3 methodologies throughout the study, techniques in Levels 1 and 2 were employed in the project. These methodologies were developed subject to specific parameters such as state and local air pollution control agency participation, funding, availability and timeliness of the receipt of requested data, and the availability of time to complete the study.

A very brief description of the emission caterories and methodologies employed in the study are presented below.

Stationary Source Fuel Combustion

This category consists of residential, commercial, institutional, and industrial fuel consumption. To determine fuel consumption for these sources, coal, fuel oil, and natural gas fuel suppliers in the 47 subject and neighboring counties (except for coal suppliers, in which a larger area was employed because of the large distance coal is transported) were inventoried by questionnaire. After determining fuel consumption totals, which were received from the questionnaires and supplemented with data from various state energy studies and surveys, point source fuel consumption totals (derived from state emissions inventories) were deleted, leaving fuel consumption totals attributed to area sources. The fuel totals were then apportioned into the various NEDS categories as needed.

Solid Waste Disposal

The project was originally scheduled to utilize state and local incineration and open burning permit files in the development of hydrocarbon emissions from these sources. Unfortunately, the permit files were either incomplete or nonexistent. Therefore, two solid waste studies were employed and Level 1 techniques, supplemented with localized solid waste generation factors, were utilized.

Nonhighway Gasoline and Diesel Fuel Consumption

The sources contained in these categories include many very small sources, such as construction equipment, snowmobiles, farm equipment, and a larger source, railroads. Railroad methodology is discussed in detail in Section V.

The primary input of data for these sources was derived from various published reports and studies. Where possible, localized data were incorporated to reflect 1975 conditions. For snowmobile emissions, an elaborate computer program was developed to account for snowmobile population density and winter weather conditions.

Aircraft and Vessels

These categories are reported together because of their similar methodologies. Data secured for both categories relied heavily on published data supplemented by various reports and surveys. Representative airports and port authorities were interviewed, but the quality and completeness of data reported by these sources was inadequate.

Hydrocarbon Evaporation Sources

This category consists of numerous small solvent consuming sources such as degreasing, printing, coating, and gasoline marketing operations and, for purposes of this study, encompasses 65 separate SIC numbers. Procedures presented in Methodology for Inventorying

Hydrocarbons (EPA-600/4-76-013) were extensively used for these sources. The methodology incorporates a very extensive questionnaire surveying technique which is discussed in detail in Section IV.

SECTION III

PLANNING CONSIDERATIONS

An essential step before executing any type of large-scale inventory is to carefully develop a thorough work plan. Alternate approaches need to be incorporated into the work plan in the event any problems arise with the initial approach, such as a limited questionnaire response, unavailability of data, time constraints, etc. This section is intended to provide some insight into areas which require special attention in the advance planning stages based upon the subject project.

Publications

The availability, accuracy, and timeliness of published documents, research reports, and studies on transportation, solid waste disposal, energy demands, etc., need to be thoroughly reviewed to determine their applicability to a project. For example, energy studies completed before 1972 are now obsolete due to the energy crisis. Also, some state and local agencies stated at the onset of the project that they had or were conducting studies which would be very useful in the PES study. However, it was realized later in the project that the agency studies, for the most part, were not adhering to their time schedules or their reports contained irrelevant material; therefore they could not be used in the PES study.

A major problem with Level 3 methodology guidelines set forth in various governmental publications, is that they are not oriented toward large-scale inventories. Therefore, many new methodologies had to be developed for this project. Also, a considerable amount of written data referenced in the publications has been outdated by more recent documents. No periodic government reference updating system is presently employed for methodology guidelines.

To acquire additional industrial reference data for the project, PES utilized many sources to better understand the quantities, uses, and types of solvents. Among the reference sources were EPA libraries, EPA publication Reports Bibliography, which is a listing of EPA reports available from the National Information Service (NTIS), and an abstract of environmental reports by nongovernment agencies, available at major public and university libraries, published papers, and interviews with various trade personnel.

Time Constraints

A major factor in most studies is the time allocated for completion of the project and of various subtasks. A project needs to be scheduled so that if there is a minor delay in one segment, work can be shifted to another segment with a minimal amount of lost time. Although this approach is easily stated, it sometimes becomes very difficult, especially when each segment of work is dependent on another segment. The problem is further compounded in the case of a major delay. This was the situation in the PES project where numerous problems delayed the completion of the project schedule. Major scheduling delays in the project were associated with the development, approval, and printing of questionnaires. Also, the slow response of state agencies in providing questionnaire mailing materials and completed responses had a rippling effect throughout the various subtasks.

SECTION IV

SURVEYING METHODOLOGY

There are two basic approaches that can be employed in obtaining a high-confidence-level emissions inventory:

- Conduct a survey of all sources in the desired SIC categories.
- Statistically sample the SIC categories and then apply the results to the entire source population.

The first approach, surveying all sources (which is designated by EPA as a Level 3 effort for evaporative hydrocarbon and fuel consumption categories) was recommended by EPA for collecting emissions data for evaporative hydrocarbon and fuel consumption categories, Although this approach provides the most reliable and accurate data when implemented to its fullest extent, some problems are encountered when applying it to a large-scale survey. A brief description of four main problems which arose in the PES study are presented below, followed by a more detailed discussion in this section.

- The development of a composite SIC source list was hampered by the vast number of sources, integrating data from a large number of references, and multiple SIC listings for a single source.
- The development and printing of questionnaires was delayed due to agency revisions and federal government requirements.
- The acquisition of fuel consumption data by surveying fuel dealers was hampered by a low response and poor quality data.
- The acquisition of data regarding drycleaning solvent usage by surveying suppliers of the solvent proved inadequate.

Composite Source List

One of the most important factors in an emission inventory is to develop a thorough and accurate source list. All data subsequently derived from the project depends, to a large extent, on the number and categorization of facilities within the source list. Therefore, PES strived to develop a thorough and complete composite source list in order to minimize the number of errors that might result from inadequate data.

PES began compiling the source list by acquiring a list of sources from National Business Lists, Inc. (NBL) for the subject counties and SIC numbers. The NBL list was then cross-referenced against Dun and Bradstreet's Million Dollar Directory and Middle Market Directory, state manufacturer directories, and trade association lists, to provide a complete and accurate composite list. The use of these references posed two problems: (1) the quality of data and source listings was poor and incomplete in most cases; and (2) some sources were listed by a different SIC number in various reference books, which necessitated a cross-referencing system not only within specific SIC numbers, but also within the entire composite source list. A solution to minimize this problem is to develop an alphabetized source list based upon NBL data which then enables one to easily recognize duplicate sources. Also, it is preferable to computerize the list to easily handle the cross-referencing system and other listing procedures.

Another problem associated with the composite source list is the vast number of sources which were found to be contained in the subject counties and SIC numbers. EPA anticipated at the onset of the project that there would be approximately 3,000 to 4,000 sources to survey. The total number of facilities contained in the composite source list expanded to approximately 13,000, not including approximately 7,000 sources in Illinois for which the survey was discontinued. This increase in the number of sources dramatically changed the scope of work for the project, and increased the cost and time involved.

A partial solution to the problem of estimating the total number of sources is to employ data from the Bureau of the Census, U.S. Department of Commerce. For example, the publication County Business Patterns 1974, gives the number of sources in various SIC categories by state and county. Although this might first appear to be an excellent solution to the problem of acquiring source totals, care must be taken in computing the total numbers since SIC sources in the census data are not always catalogued by separate SIC number; sometimes they are presented as a major group of SIC numbers.

Development and Printing of Questionnaires

PES was instructed by EPA to use and modify, where appropriate, questionnaires presented in Methodology for Inventorying Hydrocarbons. PES was responsible for reviewing the questionnaires with various state and local air pollution control agencies to incorporate their comments on the forms. The agency responses varied widely; some requested major changes, while others accepted the questionnaires as is. Since no agreement could be reached regarding the format, EPA decided to employ a detailed questionnaire to obtain as much information as possible. Therefore, sources would not need to be surveyed again in the near future for any additional studies.

One of the major time-consuming setbacks to the project was in the printing of the questionnaires. PES was originally scheduled to reproduce all of the required questionnaires, but when the number of sources dramatically increased, the number of impressions of the questionnaire also increased to an amount which exceeded that allowed for a government contractor to make in any given project (25,000). EPA then had two alternative approaches in printing the questionnaires: (1) print the forms themselves or (2) have the appropriate state agencies print the questionnaires. Because of the magnitude of problems associated with having each state print the forms, EPA decided to print the questionnaires themselves. Although this approach appears to be straightforward, many government procedural problems surfaced which delayed the printing for approximately 4 months.

The most complex problem involved the question of whether approval from the Office of Management and Budgeting (OMB) was needed for EPA to print the forms, since all government forms require OMB numbers. Also questioned was the authority of EPA to use the forms in a federal contract without OMB approval. After numerous meetings between various government personnel and attorneys, it was determined that OMB approval was not necessary since the state agencies were actually mailing the forms directly to the sources with their own cover letters. A provision of the OMB agreement was that no reference of EPA could be contained in the state cover letter accompanying the questionnaires. With this decision in hand, EPA finally began setting up the procedures for the printing of the forms. An unfortunate consequence of the decision was that PES had already begun processing state cover letters which made reference to EPA. The state agencies then had to develop new cover letters and PES reprocessed them.

Fuel Dealer Responses

To achieve reliable estimates of fuel consumed in each state and county, a very high fuel dealer response is needed from the surveying methodology. If several major county fuel suppliers fail to respond to the questionnaire, the fuel totals for that county can be significantly low. Also, the response needs to be high to off-set the overall poor quality of data which is sometimes associated with fuel dealer responses. These two cases became a problem in this study where only a 62-percent fuel dealer response was received after two mailings. Of the responses received, only 30 percent consisted of good quality data. Extrapolating this data to reflect a 100 percent return proves to be very inaccurate.

PES is presently exploring the possibility of using state energy surveys conducted in Ohio and Michigan. Data obtained from these studies will be used in conjunction with such parameters as heating degree days, housing units, and employment population to estimate the fuel totals for the other subject counties and appropriate fuel consumption categories.

Drycleaning Solvent Usage

To acquire Level 3 solvent consumption figures for the drycleaning industry, two approaches can be employed:

- Survey all drycleaning establishments directly.
- Survey all drycleaning solvent suppliers

The first approach involves a massive questionnaire mailing when applied to a large study area such as PES's project. The number of drycleaning establishments contained in an evaporative hydrocarbon emissions inventory can account for approximately 15 percent of the total evaporation sources. Although this number is not significant when applied to a small inventory, it is significant when employed in a multi-state/county inventory.

The second approach, surveying drycleaning solvent suppliers, was the method by which EPA directed PES to determine drycleaning consumption. It was determined to survey SIC number 2842, "Specialty Cleaning, Polishing, and Sanitation Preparations," which includes facilities engaged in manufacturing drycleaning preparations. It was felt that this method, if successful, would greatly reduce the time and costs associated with quantifying drycleaning solvent consumption in large-scale studies. Unfortunately, the results of surveying SIC number 2842 proved inadequate. Most of the respondents indicated that no drycleaning solvents were being manufactured at the surveyed facility. Since the results from the questionnaires were received too late to implement a new survey, Bureau of Census data were used to develop consumption values. In subsequent projects, PES has employed either Bureau of Census data or surveyed all drycleaning establishments, depending on the level of effort of the study.

SECTION V

RAILROAD METHODOLOGY

Although emissions generated by railroad operations are basically a minor component in the overall hydrocarbon emission inventory, this category posed some unique problems in data acquisition for this project. It required that PES develop alternative data collection methods to those prescribed by AQMP Guidelines. AQMP Guidelines contain the following methodology for collecting data in a Level 3 effort.

> "Determine the county diesel fuel use of rail operations from available data in transportation studies or directly from the railroads. If these data are not available, use state fuel consumption data from the MIS, and compute county share by scaling with miles of track in the county divided by miles of track in the state or approximate by county population share."

For the most part, there were no rail plans or transportation studies available that addressed fuel use, rail mileage within counties, etc. Contact with several rail companies indicated an unwillingness to provide needed data due to the size of the study area snd the unavailability of such requested data. The MIS (U.S. Bureau of Mines, Mineral Industry Survey) data is a lump sum for an entire state and is not broken down by rail company.

It was discovered during the methodology development phase, that the Interstate Commerce Commission (ICC) requires all railroads to annually submit operating data for the entire system, ranging from revenues to fuel use and locomotive unit miles for freight, passenger, and switching operations. Locomotive unit miles (LUM) are the number of miles traveled by engine units. PES also found that some of the states in the study area require the rail companies to submit similar data, but specific to that state. Therefore, fuel use and LUM were obtained for all railroads operating in the seven states from ICC and from the states that require submittal of this similar data. Other data PES obtained were track mileage and percentage of operation in each state for each railroad (one state was able to supply track mileage by county for all railroads) and the railroads operating in each county.

Where only system-wide data were available, the fuel data for each of the railroads operating within the study counties were apportioned to each state based upon that railroad's percentage of operation within the state. This fuel consumption and fuel data obtained specific to a few states was then scaled to each county by county population or track mileage by county, where available. Emissions were calculated for five engine categories (2-stroke supercharged and 4-stroke switch engines and 2-stroke supercharged, 2-stroke turbocharged and 4-stroke road engines) based on nationwide use patterns received from ASME publication 74-DGP-3, Locomotive Exhaust Emissions and Their Impact.

It is felt that the results obtained were fairly accurate based on the available information. Only one local agency (covering four counties) had any significant comments on PES's draft data. PES estimates were then revised to reflect this localized data.

SECTION VI

AGENCY PARTICIPATION

As can be expected in a project encompassing many state and local air pollution control geographical areas, problems arise in synchronizing the activities of the project to conform to the wants and needs of the various agencies. Also, the varying degrees of cooperation received from the agencies plays a significant role in the development of a project.

Task Response

The response to various subtasks of the project by several agencies was very slow, necessitating many revisions to the project schedule. As an example, state questionnaire mailing materials were received up to 2 months late. Also, comments from state agencies on PES draft subtasks were sometimes received very late, necessitating changes in the project schedule. It should be noted that the majority of involved agencies attempted to respond in a timely manner and for the most part succeeded, but nevertheless a slow response by one or two agencies can cause serious planning problems.

Another example of slow response to a task by an agency was exemplified during the questionnaire mailing. As the questionnaires were being packaged for mailing, one state agency suddenly decided to allow local agencies to participate in questionnaire mailing. PES then had to sort and repackage the questionnaires which involved lost time and costs to the project.

Agency Contact

Another factor which plays a significant role in a study involving many agencies is the agency's project contact. This individual plays a key role in maintaining liaison with EPA and the contractor. The individual needs to be kept abreast of all parameters associated with the project to enable the incorporation of pertinent agency data for use in the project. If the agency contact is transferred to another position in the agency or leaves the employment of the agency, as happened in the PES study, serious problems can develop. Prior verbal commitments, knowledge of the project, and experienced working relationships can be lost. These problems may appear minor but can significantly alter various subtasks of the project.

SECTION VII

CONCLUSIONS

As presented in the text of this paper, a number of methodology considerations need to be assessed in conducting a Level 3 inventory for a large study area. Although Level 3 studies are oriented towards and easily adapted to small inventories, time constraints and cost considerations hinder their use in large studies. As an example, when inventorying evaporative hydrocarbon sources the magnitude of sources to be surveyed is directly related to the size of the study area. As in the case of the PES study, approximately 13,000 sources were surveyed. Minor errors in planning, such as the printing of questionnaires, and compilation of a composite source list, are significantly magnified by a large amount of surveyed sources.

Although many problems were encountered in this project, with the help of EPA and state and local air pollution control agencies, the results from the completed subtasks have been reviewed favorably. Approximately 80 percent of the project has been completed. PES is presently recontacting fuel and evaporative hydrocarbon sources who failed to respond to the initial questionnaire mailing.

CONDENSED DISCUSSION

Question: Is the idea of trying to inventory 47 counties from a single centralized point realistic, ending up with 20 thousand questionnaires?

Trapaso: It was thought that there would be only three to four thousand sources. When you start considering 25 tons per year potential and lower, however, you run into a lot of sources and this number of 20 thousand sources doesn't even consider dry cleaning establishments or gasoline stations which account for a significant amount of emissions, too.

Question: Do you have any comments on practical ways to avoid this problem?

Trapaso: In some of them as far as coming up with the total number of sources in the different SIC categories, one quick method is to go to the Bureau of Census data, and from that try to get a ball park figure of how many sources are actually talked about. We have done this in subsequent projects and it has given us a good general figure.

AIR FORCE EMISSION INVENTORIES

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Frequently, the Air Force must develop air pollutant emission inventories. Emission inventories are required to support environmental impact analyses for proposed weapon systems development and deployment and significant changes in operations of Air Force installations. Emissions inventories of Air Force activities are sometimes required by pollution control agencies for their planning and policy decisions. The Air Force must also comply with appropriate pollution control statutes. The cost of compliance, however, must be considered a nonproductive investment since it does not contribute to our defense capability and must compete for funding within a continually tighter budget. Accurate and complete emissions inventories go a long way toward developing a cost effective pollution control strategy within current Department of Defense fiscal constraints.

The Air Force has developed a tool to simplify and standardize emission inventories. It is called the Air Quality Assessment Model (AQAM) and actually does far more than emission inventories. It is a complex dispersion model that combines operational and meteorological inputs to predict downwind concentrations of five pollutants from multiple sources of various geometries. One of the essential elements which in part determines the accuracy of these predictions is the Source Inventory Program. It has numerous independent uses in addition to providing the emissions information for the Long and Short Term Dispersion Models. This discussion will be limited to a description of the Source Inventory Program and the emission factors and data sources developed for it.

One of the unique features of AQAM is its treatement of military aircraft operations. Military aircraft operations are significantly different from their civilian counterparts in several ways. The touch-and-go landing cycle, for instance, is performed routinely at nearly all Air Force installations, while its use is very limited at commercial airports. A model of the touch-and-go cycle was developed for each Air Force aircraft type and included in AQAM to differentiate these emissions and their locations in three dimensional space from the standard landing-takeoff (LTO) cycle. Also, LTO cycles used in AQAM are site specific. That is, the geometry of each airport's parking areas and taxiways, and individual aircraft taxi speeds and other operational descriptors are used. The effort required to attain this increased accuracy is justified by the relative importance of these emissions. Ground operations constitute a significant fraction of total aircraft emissions and are even more important to air quality impact because they are not as dispersed as emissions in flight.

The Air Force operates numerous engines which are significantly different than those of civil aircraft. Many are equipped with afterburners. Some are very old designs which are no longer in commercial service. Since accurate emissions data for these engines were not available, we undertook a comprehensive emissions measurement program to develop emission factors for virtually all Air Force engines. This included five pollutants in each of three engine modes (four when afterburners are equipped) for 23 different engine types. In all, exhaust samples were collected from 103 engines and from three to ten replicates each. These were engine exhaust plane measurements. A follow-on project is underway to model the reactions which might take place in the afterburner exhaust downstream of the tailpipe to better define the pollutants which finally reach equilibrium in the atmosphere.

The field testing of the AQAM inventorying procedure was accomplished during 1975-76. Ten Air Force and three Navy bases were inventoried and modeled. Field data collection methods were tested and refined. A revised field data collection manual is currently in draft form and will be published for potential AQAM users.

The AQAM model has been released for public use and is generally applicable to any airport environment. At least one consulting and research organization has already used it in conjunction with civilian airport development. Although the Air Force has no charter to develop anything specifically for the civilian community, we are pleased that DOD research dollars are having civilian spin-off benefits. We are hopeful that our product will find wide application.

In addition to aircraft, AQAM is capable of handling a wide variety of stationary sources and surface vehicles of all types. Emission factors from AP-42 and API publications have been programmed for most sources and are updated as new data becomes available. Input to the emissions inventory consists primarily, then, of operational data such as throughput, fuel rate, fuel type, vehicle miles, source type, etc. Although the Source Inventory Program calculates predicted emissions, the data requirement is still extensive. As a minimum, a units conversion is usually required to transition from operational records to computer input. In many cases the data must also be manually sorted or combined into appropriate time blocks. Frequently records are available for the total air base, but not the specific source in question. In those cases engineering estimates must be used to allocate to each individual source its appropriate share of natural gas, for example. Most commercial customers consist of only one source or are individually metered. By contrast, an entire Air Force base may have only one gas meter, or records of heating fuel may reflect only total deliveries to the base with no way to accurately track subsequent disbursements to the locations where the fuel was actually burned. The data collection phase, which appeared on the surface to be a simple square filling exercise, in fact turned out to be very labor intensive. We plan to complete a sensitivity analysis in the near future to streamline the data requirements. Hopefully, we can reduce the manhours significantly by eliminating some of the detail currently required. We do not want to reduce accuracy which would inevitably result if data were eliminated. Therefore, other indicators which may be more readily available will be sought and subroutines developed which will transpose these somewhat grosser figures into the detail required for accurate emission inventories and dispersion modeling. The area where we may benefit most is motor vehicles. Currently, vehicle miles travelled on each line or area for each of six vehicle classes are required. Data in this much detail is seldom, if ever, available. Consequently, a myriad of records must be combed and correlated to make even the most perfunctory estimate. Hopefully, other more readily available figures can be transposed through computer analysis to provide the required input.

Those sources for which no emission factors exist can also be modelled by AQAM, but the emissions must be calculated off line and input to the emission inventory and dispersion models as metric tons of each pollutant emitted annually. There are no commonly occurring sources for which we do not have preprogrammed emission factors, but occasionally a deisel electric generating plant or some other unique source is encountered. One source common to most Air Force bases for which a data weakness exists is aircraft ground support equipment, or "powered AGE." Our best estimates indicate that this is not usually a significant source, but we would like to better define the problem.

Based on the data developed from our initial 13 base study, we intend to develop a general Air Force control strategy to minimize our air quality impact. There appear to be no statutory constraints driving these control efforts. In developing control strategies, we will consider both structural and non-structural alternatives and cost effectiveness. For example, changes in aircraft operating procedures could reduce emissions, while staggering working hours could reduce temporal peaks from automobile traffic.

The Environmental Management Systems Division of our organization is developing a methodology for preparing air base comprehensive plans. Control and dispersion of air pollutants will be one factor considered in comprehensive planning. We hope to identify problems and alternative solutions which will support that phase of the comprehensive planning process. Siting of new facilities, modifications to automobile traffic flow and structural and vegetative influences on wind flow fields are some of the things to be considered.

Our primary finding to date is that aircraft and automobiles generate an overwhelming majority of air pollutant emissions at most Department of Defense air installations. Aircraft at active bases sometimes emit more total pollutant mass than automobiles, but these pollutants are well dispersed due to the geometry of aircraft flight paths. Aircraft and surface vehicles, then, have the greatest influence of any source category on ambient air quality. This is understandable when one considers that even at our major aircraft overhaul facilities there are very few of the traditional "dirty" industries such as foundaries, smelters, or coal fired generating plants. The only significant impact most Department of Defense air installations might have is their contribution to local ambient hydrocarbon concentrations. This is attributable in part to transfer, storage, and consumption of significant quantities of fuels and solvents. I must point out, however, that these levels are predicted from modeling, not measurements. Even if the predicted hydrocarbon concentrations are verified, their relationship to health effects is not well defined.

In closing, I would like to point out some of the limitations we are working under and tools or data we have need of. I described to a limited extent our aircraft turbine engine emissions measurement program. We have noted a rather large standard deviation among exhaust hydrocarbon samples. This standard deviation was much greater than that of either carbon monoxide or oxides of nitrogen and coincides with the findings of other investigators. We suspect that this may be due to the method of analysis. A flame ionization detector (FID) is the prescribed method of hydrocarbon measurement from aircraft exhaust plumes. There may be some unexplained variation in the FID response to different hydrocarbon species. Another possibility is the extractive technique. A number of discrete samples are taken from different locations within the plume. The non-homogeneous nature of the plume at the sampling point could explain the large standard deviations.

We need more data on emission factors for powered aircraft ground support equipment (AGE). We are currently using some rather general emission factors compiled from measurements of similar but not identical equipment. Fortunately, AGE emissions appear to have minimal impact at most locations. As other sources are controlled, the relative importance of AGE emissions may become significant, and an effort should be made to better define their emissions. An emissions measurement program appears to be the only satisfactory alternative.

An area in which I am pleased to note significant research being conducted is emissions from storage and handling of petroleum products. Nearly every Department of Defense airfield handles relatively large quantities of jet fuel and in some cases gasoline. Based on our current estimates, processing these fuels may contribute a significant share of the bases' total hydrocarbon emissions. Since predicted hydrocarbon concentrations are the only ones that ever approach ambient standards, we would like to be more confident in the accuracy of our emissions estimates.

I already mentioned our desire to streamline our motor vehicle inventorying procedures. We continually update our preprogrammed emission factors as they are changed in AP-42. Our vehicle algorithm requires a knowledge of the vehicle age distribution among each of the vehicle classes, and the vehicle miles of each vehicle class driven along each vehicle line source or within each vehicle area. Vehicle age distribution can be ascertained and associated emission factors are readily available, but vehicle miles are another matter. What we need is an algorithm that will arrive at vehicle miles without expensive traffic surveys and vehicle counts. We would like to develop an algorithm using airbase vehicle population, size of work force, number of employees at various work centers, operating hours of installation activities, etc., to derive vehicle miles for each source.

The refinements and improvements I have just mentioned are in the "nice to have" category for the moment. We fully intend to pursue them, but we already have what I consider a most useful tool in AQAM which is finding application in the civilian as well as military community. It has helped define the scope of the Air Force's air quality impact and identified the significant sources and pollutants which we will seek to control.

CONDENSED DISCUSSION

Question: Would it be possible to obtain the factors you developed for jet engine test cells and your touch and go landing procedure along with the test data? Is that public information?

Grems: Yes, it is. I can't remember the report number right now, but it's available through NTIS. The emission factors for the engine test cells that we are using now are simply the emission factors developed for the engines themselves. We find very little, if any, change between the exhaust plane measurements and the exit plane of the test cell.

Question: You mentioned that your application included motor vehicles as well as aircraft emissions. Are different factors utilized for these sources on Air Force bases or are the situations the same as general usage?

Grems: I'm not so sure that in the emission factor area, it's not different. I think we have probably done the inventory in more detail than is generally done. We have, as I said, categorized the vehicles by age distribution, by vehicle type, and by individual lengths over a very

Grems: (con't) small area, usually a couple of square miles. And we have a number of lengths within a very small area. That will probably be the only real difference.

Question: To whom is the model and supporting data available?

Grems: The documentation of the model and how to use it, etc., is available through NTIS. The model itself would have to be obtained through the Air Force Systems Command channels. They control all our computer products. So, if you wanted the computer code itself, you would write to the Air Force Headquarters Systems Command at Wright Patterson Air Force Base, Ohio. They will ultimately send that request to us, but it has to go through channels before I can release it.

Question: What are the plans for using the model at each of your air bases to come up with their own inventories? Are there any plans down stream to do that?

Grems: Yes, it's phased over the next two or three years. As I say, we develop a procedure and we turn it over to another Air Force agency for implementation and I haven't followed exactly what their schedule is. We have about 50

CONDENSED DISCUSSION

Grems: (con't) air bases, though, with a major flying mission which we would plan to inventory over the next couple of years. We have done 10 and that leaves about 40. Those bases which have already been done will probably be updated periodically.

Question: Do you have a correlated ambient monitoring system or do you plan one? Have you validated your model?

Grems: The validation process has just been finished at Williams Air Force Base in Arizona near Phoenix. It is about a two year process. I think they have about a year and a half worth of actual monitored data. That includes operational information, meterological and ambient measurements, which they are now in the process of sorting and trying to get a validation from.

Question: Has the Air Force spent any efforts with regard to the rocket emissions at Cape Kennedy and other places?

Grems: I'm not aware of any. I'm sure that the various space and missle systems offices which wrote the impact statements for the different missle deployments have had to address this topic in

CONDENSED DISCUSSION

Grems: (con't) their impact statements to justify the use of the missle. I don't know what the actual factors might be, however.

Question: We have a weapons disposal depot in our area that kind of has an unusual problem. They detonate about a hundred thousand tons of explosives three times a week and we have no emission factors or no possible way of estimating it. Do you know of any work that has been done in the field or anything that is planned in that area?

Grems: No, I was not aware that we had such a facility or a requirement for that information.

Comment: I don't believe that is an Air Force facility. Disposal is all they do. They blow up munitions three times a week, and shake the earth all over. They obviously have a tremendous particulate emission, but we don't know what the hydrocarbon emissions are and have no way of estimating it.

A FORMAT FOR THE STORAGE OF AREA SOURCE EMISSION DATA

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Abstract

A format is presented for storing area source emission data. Area sources are small, dispersed sources of air pollution which individually emit small quantities of pollutants, but in aggregate may significantly affect air quality. Descriptions of the structure of the storage format and each data field are presented.

The format was developed to provide a consistent and uniform statewide area source emission data base for inventory, modeling and strategy evaluation activities. It will accommodate the limited data currently available, but has the capability of storing very detailed source data as future needs develop. The format includes data fields for information on the spatial and temporal distribution of area source emissions and provides for simple documentation of process and emission data.

Introduction

Emission inventory, modeling and strategy evaluation activities require a comprehensive and consistent base of point source, area source and motor vehicle emission data. Regional air quality models require detailed information on the spatial and temporal distribution of emissions. Detailed information on emissions from different emission processes and source types are needed for strategy evaluation.

For point sources, or individual plants or points which emit significant quantities of air pollutants, the Environmental Protection Agency (EPA) has developed the Emission Inventory Subsystem (EIS) to store emission and source data. The EIS data storage format includes data fields for information on the spatial location of emissions, the operating schedule or temporal distribution of emissions, and detailed emission factors and operating rates for the various emission processes.

Unlike point sources, area sources of air pollution are small, dispersed sources which individually emit small quantities of pollutants. Typical area sources are fuel burning in home heaters, agricultural field burning, and evaporation of solvents used in architectural coatings. Although area sources are individually small, in aggregate these sources may significantly affect the overall air quality. For example, approximately one half of the organic gas emissions from stationary sources in California in piston" aircraft operations, the process rate must be reported as total "military aircraft" operations.

Thus the NEDS system does not adequately provide the detailed and documented emission inventory data needed for strategy evaluation and air quality modeling in California.

This paper describes a format for storing area source emission data which provides data fields for information on the spatial and temporal distribution of emissions and on the emissions from the various processes. A discussion of design considerations is followed by a description of the data format structure and a discussion on applications of the format developed. The data to be entered into each data field are described in the Appendix.

Design Considerations

The area source data storage format is designed to

1. include the detailed spatial and temporal data needed for air quality modeling,
2. include process-level data for strategy evaluation,
3. accomodate the wide variety of area source information available,
4. include simple confidence ratings and documentation for evaluating data reliability, and
5. accommodate information on organic gas constituents and particle size distribution as it becomes available.

Data Format Structure

In the area source data storage format, data are organized into two levels, an activity level and a process level, as shown in Figure 1.

A separate entry is made at the activity level for each different major source category and activity (e.g. architectural surface coatings, non-point industrial and commercial surface coating, non-point degreasing). Separate entries are also made for similar activities with different spatial location (e.g. two different airports in a county).

The process level is subordinate to the activity level and includes information on the different emission processes associated with a given emission activity (e.g. different types of aircraft operations at an airport).

The relationship between the two levels can be seen more clearly in Figure 1, which shows the different Level I (Activity) listings that might be created for the emission category of "aircraft" in a hypothetical county with two airports, "Metro Airport" and "Air Force Base". In this example, "Metro Airport" is a commercial airport which has some military and general traffic. Thus separate (Level I) Activity files are created for military and general aircraft. The second airport, "Air Force Base", has only military traffic and a Level I file is required only for the military operations. Subordinate to each activity are one or more process entries related to the different types of aircraft (e.g. jumbo jet, long range jet, and medium range jet) associated with the different Level I airport activities.

The data fields which make up each level are organized into groups, as shown in Table 1. The activity level (Level I) includes the groups "identification key," "activity identification," "spatial distribution" and "temporal distribution." The process level (Level II) repeats the identification key and includes the groups "process identification," "process information," "pollutant information," and "emission estimates". Each group is discussed below and the data fields are described more completely in the Appendix.

Identification Key - This appears in both the activity and process levels and contains codes which identify the inventory category and activity as well as the state, county, and air basin* for which the data are collected. The key provides a basis for sorting emission data into general inventory categories or for segregating emissions on a state, county, or air basin basis. The key also includes the date the file was last reviewed and a file number to distinguish between areas which have the same activities but different spatial or temporal characteristics.

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* In California air basins are similar to the federal air quality control regions, but in some cases have different boundaries. Some counties lie in two air basins; in this case a separate set of area source data is maintained for each portion of the county.

Activity Identification - These data fields are used to describe the activity in detail. Specific data fields included are activity name, file name, associated EIS plant I.D., and activity comments. A typical activity name would be "general aircraft emissions." An example of file name would be "Los Angeles International Airport". The associated EIS plant I.D. is used if the area source is associated with a plant included in the EIS system. General comments, warnings, and limitations may be included in the activity comment field.

Spatial Distribution - This group is used to identify the Air Quality Control Region, to define the area in Universal Transverse Mercator (UTM) coordinates and to identify a population, land use or economic parameter to distribute emissions over a defined area. There are two options for defining the area. If the area source has a fairly simple shape, its boundaries may be described with up to six pairs of UTM coordinates. If it has a more complex shape a reference code may be included in the defined area field.

This code would provide reference to an external file containing a digitized boundary description of the defined area.

A distribution parameter code is included for identifying an appropriate land use or population parameter to distribute emissions spatially within the county or within the defined area. A separate file of digitized land use or population data is used in conjunction with this code.

Temporal Distribution - These data fields describe the typical operating schedule of the source. The monthly and hourly throughput, or percentage of yearly throughput in each month and daily throughput in each hour,are included. Also included are fields for the hours of operation per day, days of operation in each week, weeks of operation per year, and the ratio of maximum daily throughput to average daily throughput.

Process Identification - This group is used to identify the process code; to specify units other than the standard units associated with the process code; to name the process; and to identify the relevant, EPA-developed Source Classification Code (SCC). The SCC is used to facilitate reporting to EPA. The ARB process code is more detailed than the SCC and permits more precise definition of processes.

Process Information - This group of data fields contains further information about the process and its operating rate. Specific data fields are inventory year, the annual process rate, the source of the process rate data (e.g. company or governmental agency), relevant comments on how the process rate data were developed, a confidence rating, the maximum hourly process rate, the sulfur, ash, nitrogen and heat content of fuels burned, and any general comments on the process.

Pollutant Information - This group contains the SAROAD pollutant code and information on emission factors. Along with the emission factor are included fields for the source of the emission factor, any significant comments on how the factor was developed, a confidence rating, applicable control regulations, the percentage of control represented in the emission factor, the last date the factor was reviewed, and a field for referencing more detailed information on organic gas constituents or particle size.

Emission Estimates - Given the information in the other data fields we expect to use the computer to calculate emission rates. Average annual emissions and maximum hourly emissions will be calculated along with an overall confidence rating for the estimate of emissions from the process.

Application

We expect to use the format described above as we compile area source emission data for a 1976 inventory in California. Codes for specific fields within the format have been developed and are discussed in a separate report.[1] Some revision to the format and codes may occur during the next year as the format is implemented.

Summary

A format for the computer storage of area source data was developed which has advantages over the NEDS area source system. The format provides for:

1. data fields describing both the spatial and temporal distribution of emissions;
2. accommodating a wide variety of area source information from gross emission estimates for major categories to detailed emission estimates for individual processes; and
3. documenting the source and the reliability of emission factors and process rates.

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[1] A Format for the Computer Storage of Area Source Emission Data. Draft Report, California Air Resources Board, Technical Services Division, July 30, 1977.

FIGURE 1

AIR RESOURCES BOARD

AREA SOURCE DATA FORMAT: TWO-LEVEL CONCEPT

EXAMPLE - AIRCRAFT EMISSIONS

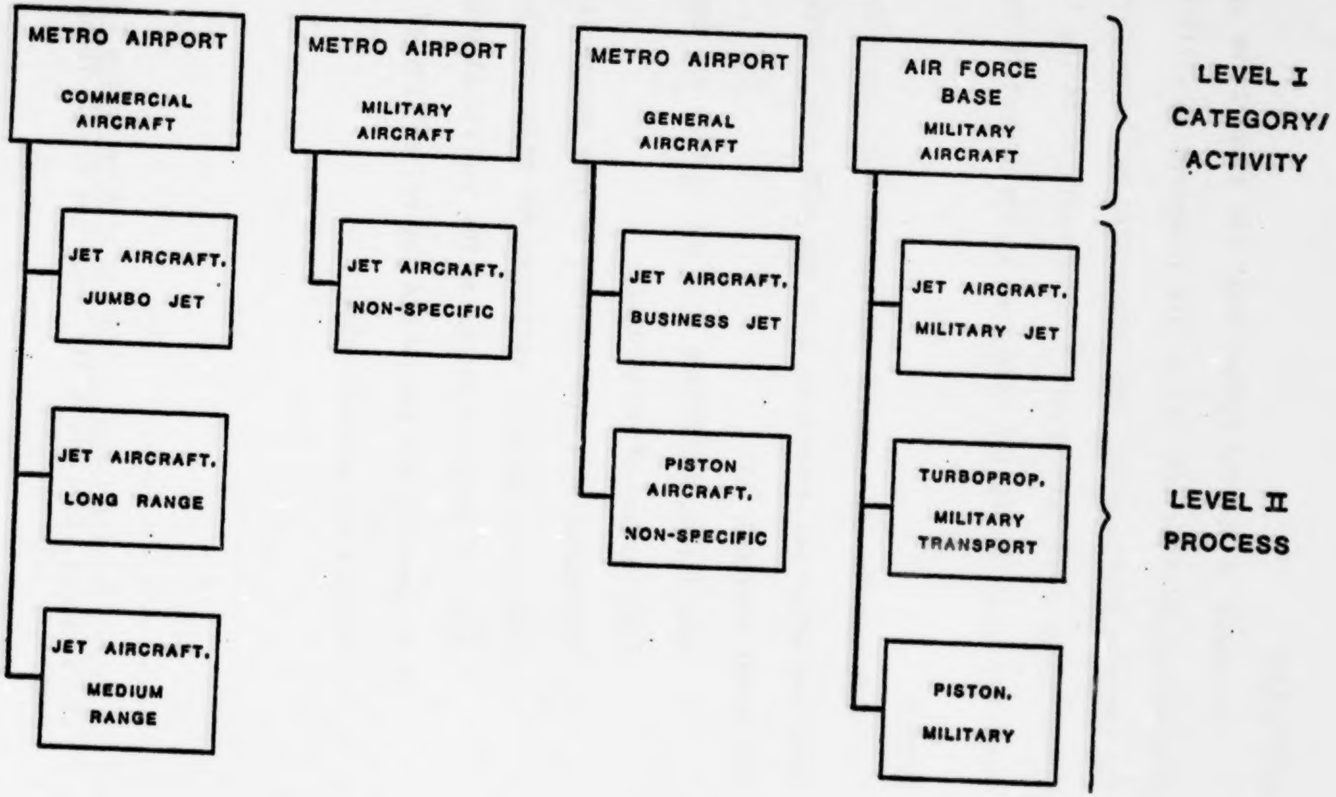
METRO AIRPORT
COMMERCIAL AIRCRAFT
JET AIRCRAFT, JUMBO JET
JET AIRCRAFT, LONG RANGE
JET AIRCRAFT, MEDIUM RANGE
METRO AIRPORT
MILITARY AIRCRAFT
JET AIRCRAFT, NON-SPECIFIC
METRO AIRPORT
GENERAL AIRCRAFT
JET AIRCRAFT, BUSINESS JET
PISTON AIRCRAFT, NON-SPECIFIC
AIR FORCE BASE
MILITARY AIRCRAFT
JET AIRCRAFT, MILITARY JET
TURBOPROP, MILITARY TRANSPORT
PISTON, MILITARY
LEVEL I
CATEGORY/
ACTIVITY
LEVEL II
PROCESS

TABLE 1

Outline of the Area Source Data Fields

LEVEL I: ACTIVITY

- Identification key
  - State code
  - County code
  - Air basin code
  - Date
  - Category/activity code
  - File number
- Activity identification
  - Activity name
  - File name
  - Associated EIS plant I.D.
  - Activity comments
- Spatial Distribution
  - AQCR
  - UTM-described area*
  - Defined area*
  - Distribution parameter
- Temporal distribution
  - Monthly throughput
  - Hours per day
  - Days of the week
  - Weeks per year
  - Hourly throughput
  - Ratio of daily throughput

LEVEL II: PROCESS

- Identification key
  - (same)
- Process identification
  - Process code
  - Units
  - Process name
  - Source Classification Code
- Process information
  - Inventory year
  - Annual process rate
  - Source of annual process rate
  - Process rate comments
  - Confidence rating for annual process rate
  - Maximum hourly process rate
  - % Sulfur
  - % Ash
  - % Nitrogen
  - Heat content
  - process comments
- Pollutant information
  - Pollutant code
  - Emission factor
  - Source of emission factor
  - Emission factor comments
  - Confidence rating for emission factor
  - Control regulations
  - Percent control
  - Review date
  - Pollutant-specific data
- Emission estimates
  - Average annual emissions
  - Confidence rating
  - Maximum hourly emissions

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*Either field, not both, will be used

APPENDIX

Description of the Area Source Data Fields

State Code

The two digit state code is identical to the code used in NEDS/EIS.

County Code

This two digit code is also identical to that used in NEDS/EIS.

Air Basin Code

This is a three digit field. If a county lies in more than one air basin then data must be provided for each portion of the county. This data field in the key differs from the EIS point source file which specifies the Air Quality Control Region.

Date

This five-digit field is used to record the date on which the area source data associated with the key was last reviewed or changed. As in NEDS/EIS, it is expressed as the Julian date: the first two digits identify the year and the last three digits indicate the number of the day.

Category/Activity Code

The first two digits of this four-digit code identify the inventory category into which the emission data will ultimately be placed. Within each inventory category are one or more emission-producing activities with distinct spatial and temporal distribution characteristics. The last two digits in this field identify the activity associated with the emission data.

File Number

This two-digit number is used when the same activity occurs with different spatial or temporal characteristics. For example, two commercial airports located within a single county are assigned different file numbers. Files are numbered sequentially.

Activity Name

The activity name or description may be indicated in this 20 space narrative field.

File Name

This 20-space narrative field may be used to name the file which is numbered in the identification key.

Associated EIS Plant I.D.

This four-digit field may be used to relate emissions from an area source to a plant (point source) identified in EIS. For example, an oil refinery is given a plant I.D. number and inventoried as a point source in EIS with all emissions assigned to points within the refinery boundaries. However, the refinery may be the source of additional fugitive emissions which are emitted from many points within the refinery area. These fugitive emissions are spatially distributed over the refinery area and may be inventoried as an area source, but can still be related to the plant and to the point source emissions in EIS.

Activity Comments

A sixty-four space field is provided so that comments of general nature, including warnings, limitations or suggestions regarding activity information, may be entered.

AQCR

This field contains the three-digit code for the air quality control region in which the activity lies. If emissions occur in more than one AQCR, separate activity files will be created for each AQCR.

UTM Described Area

UTM coordinates are used to describe the distribution area as a figure with up to six sides. This 57-space field defines the UTM zone and up to six pairs of UTM coordinates. This field may also be used to describe a line source. A "0" in the last space of the field indicates that the first and last points should be joined to form a closed area, while a "1" in that space indicates that emissions are distributed along the line described by the UTM coordinates.

Defined Area

A three-digit "defined area" code is used instead of UTM area descriptors when an area is too large or complex in shape to be described by six coordinates. The code number references other computer programs which contain digitized boundary information for the area. For example, it may be defined as the eastern half of a county or as terrain above a specified altitude.

Distribution Parameter

This field contains a four-digit distribution parameter. These parameters, such as land use classification, population or economic activity, will be defined and coded as needed in each area. The code indicates to which land use classification or economic activity area the emissions should be allocated within the "UTM-described area" or the "defined area." As an example of the application of the spatial distribution method just described, assume that 20% of all residential wood burning in the SCAB portion of San Bernardino County is done at homes having an altitude greater than 3000 feet. The field "defined area" would contain a code number for the areas above that altitude, and in the field for "distribution parameters" would be the code indicating "residential land use."

Monthly Throughput

The percent of the total yearly throughput processed in each month is indicated in each of 12 two-digit fields.

Hours Per Day

This two-digit field indicates the number of hours per day the emitting activity typically operates. In the case of an activity such as orchard heater burning, which does not occur on a daily basis, the number of hours per actual operating day is entered here.

Days of the Week

This eight-digit field is used to indicate the days of the week during which the activity typically occurs. If the days are random, the number of days per week the activity occurs will be entered.

Weeks Per Year

This two-digit field is used to indicate the number of weeks during the year in which the activity takes place.

Hourly Throughput

The percent of the daily throughput processed in each hour of a typical operating day is indicated in each of the 24 two-digit fields.

Ratio of Daily Throughput

The ratio of daily throughput data field, consisting of a three-digit number and a user-specified decimal point, provides an indication of how much the operating schedule of the activity may vary from the average. Many area source emissions occur infrequently and for brief periods of time; although the total annual emissions averaged over the year may indicate a small daily output, emission levels while the activity is operating are quite high. The ratio of maximum daily to average daily throughput (process rate for the inventory year divided by 365 days) gives an indication of what "worst case" emissions could be. As an example, the ratio of the maximum tons burned on any day on which a forest fire occurred to the average number of tons burned per day (total tons burned in all forest fires in the activity area during the inventory year, divided by 365) is a proper ratio of throughput.

Process Code

This eight-digit code describes the emission-producing process. The first two digits of the code provide a general description of the physical process in or by which emissions are produced or released. These physical processes are combustion of fuels, incineration, evaporation, and fugitive loss. Combustion of fuels is the process of internal or controlled external combustion which occurs during the generation of power, heat or light. Conversely, incineration is controlled or uncontrolled combustion in which the resultant energy is not utilized. Thus the burning of agricultural waste as fuel for a boiler is regarded as combustion of fuels, although the burning of that same waste in a field is incineration. Evaporation is simply the loss of vapors to the atmosphere which occurs during the transfer, storage or use of organic materials. Fugitive losses include processes other than evaporation through which emissions enter the air, including the processes of entrainment of dust and other particulates, and the pulverization or abrasion of surface materials by mechanical or natural force.

The next three digits of the code describe the specific application of the process. Applications include "jumbo jets," "utility equipment" and "light duty motor vehicles" under the physical process of "combustion of fuels," and "vehicle tank filling" and "cleaning" under the "evaporation" process.

The last three-digit portion of the code indicates the fuel or product consumed or operated upon in application of the described process. In the case of "combustion of fuels - utility equipment," the fuel or product consumed could be gasoline or diesel fuel.

Units

Associated with Part 3 of each process code are units of throughput (such as tons or 10^3 gallons). These units are used to express the process rates and emission factors for the coded process. If this field is left blank, it will be assumed that the emission factor and process rate units correspond to those specified with the process code. If the specified units are not appropriate for the calculation of emissions, alternative units may be chosen and a corresponding code entered in this two-digit "Units" field.

For example, the process rate units for aviation gas and jet fuel are 10^3 gallons, so the emission factors are expressed in lb/10^3 gallons. However, aircraft emissions are commonly expressed in terms of landing-takeoff cycles; consequently, the units of "landing-takeoff cycles" would be used for the process rate (both yearly and maximum hourly) and the emission factors. The code corresponding to "landing-takeoff cycles" would be entered in this two-digit field.

Process Name

This data field is used to describe the process when a general or non-specific process code is used.

Source Classification Code (SCC)

The eight-digit SCC is an EPA developed code which is related to both activity and process. The appropriate area source SCC is entered so that,if necessary, area source emissions can be sorted according to those classifications and reported to EPA in NEDS (National Emissions Data System) format.

Inventory Year

The two digits in this field indicate the year for which the process information is applicable.

Annual Process Rate

Up to nine digits may be placed in this field to indicate the throughput during the inventory year of the fuel or material described in the process code. The decimal point must be specified. The process rate must be expressed in units which correspond to either the process code or those specified in the Units field.

Source of Annual Process Rate

This twenty-six space field consists of two parts. The first space contains a one-letter code which indicates the type of source from which the rate information was received, such as a utility company or a state or federal agency. The remaining twenty-five space narrative field contains the name of the source company or agency and/or the person supplying the data.

Process Rate Comments

Occasionally, process rate data are received from the source in a different form than the number which is presented in the Annual Process Rate field. For example, architectural surface coating usage data may be available from the source as a statewide total, and distribution to counties is made on the basis of population. Thus the data that go into the Process Rate field are based on, but not identical to, the data received from the source.

In this case, a summary of the procedure by which the input data was derived will be placed in this 20-space narrative field.

Confidence Rating for Annual Process Rate

This one-digit code is an evaluation of the reliability of the process rate information.

Maximum Hourly Process Rate

The maximum hourly process rate is an estimate of the maximum throughput that can occur in any hour. Nine digits may be placed in the ten-space field, the decimal point must be specified, and units must be consistent with those of the process.

%Sulfur

Two digits and a decimal point in this field indicate the sulfur content of the fuel processed. If this information is not applicable to the process, the field will be left blank.

%Ash

Two digits and a decimal point in this field indicate the ash content of the fuel processed. As above, the field will be left blank if the information is not applicable.

%Nitrogen

The quantity of nitrogen in the fuel is indicated to three decimal places in this field. The decimal point is fixed.

Heat Content

The gross heating value, in 10^3 BTUs per process code units, is entered to four significant figures in this field. The decimal point must be specified.

Process Comments

This 20-space narrative field may be used for general comments regarding assumptions, process data limitations or concerns regarding the use of the process data.

Pollutant Code

This five-digit SAROAD code identifies the pollutant (e.g. carbon monoxide or total organic gas) produced in the specified process.

Emission Factor

The emission factor indicates the quantity of pollutants generated for each unit of throughput (controlled emission factor). This nine-space field contains an eight-digit emission factor and a user-specified decimal point. Because emissions will be calculated directly using this input, the emission factor must be expressed in units which correspond to either those of the process code or those specified in the Units field.

Source of Emission Factor

The first space of this two part, 26-space field contains a one-digit code number indicating the type of source; the remainder of the field contains the name of the person, company, agency or publication which provided the factor.

Emission Factor Comments

If the emission factor received from the source differs from the figure placed in the Emission Factor field, the method of conversion must be summarized in this 20-space narrative field.

Confidence Rating for Emission Factor

A code is used in this one-digit data field to rate the reliability of the emission factor.

Control Regulations

In these twelve spaces, control regulations are included in a narrative form to indicate what, if any, controls (devices or legal limitations) are in effect or are anticipated which affect the process or its emissions.

Percent Control

This two-digit field is used to indicate the percent control represented by the emission factor. A blank indicates the percent of control is unknown and a zero indicates an uncontrolled emission factor.

Review Date

The month and year in which the emission factor was last reviewed and determined to be the best currently available are indicated in this four-digit field.

Pollutant-Specific Data

This nine digit field is used to provide supplementary information for each pollutant. For instance, this field will eventually contain particulate size range information for total suspended particulate emissions (e.g. it may show the percent of total emitted particulates with average diameter less than 2µ, less than 7µ and less than 10µ). In the case of organic gas emissions, this field may contain a code number referencing typical organic constituents for the process.

Average Annual Emissions

Total emissions of each pollutant from each process are calculated from the process rate and the emission factor, and are stored and reported in tons per year.

Confidence Rating

The confidence rating for the process rate and the emission factor are used by the computer to calculate a confidence rating for the estimate of yearly emissions.

Maximum Hourly Emissions

These emissions are calculated by the computer using the maximum hourly process rate, and are stored and reported in pounds per hour.

CONDENSED DISCUSSION

Question: Could you relate your procedures more specifically? Let's say you've got a three pump gasoline service station. Are you going to pump all the data for this one gas station or are you going to punch all the data for a square mile or a half square mile of downtown Los Angeles?

Bradley: We have two ways of handling gasoline stations in California. One is to include them in as a separate point source in the EIS data system. That system can now accomodate sources down to those emitting one ton per year of any one pollutant. The systems that EPA has distributed can only handle the resolution down to one ton, although it is possible to go into decimal figures, if you really want to. The split between point and area sources can be separated dependent upon how much resources you have. We are actually going to break down a number of the area sources, for example, the architectural coatings. You will hear later in the conference about a State wide emission estimate that has been developed for architectural surface coatings emissions. This information will be broken down

CONDENSED DISCUSSION

Bradley: (con't) to each county. Within each county, these emissions will be distributed using a population parameter. Information that is available on various categories will be utilized to develop the temporal information on the emissions and their patterns. The special element can be provided for within the system by going to the subcounty level and defining the major urban area boundaries by using the distribution parameter to population and utilizing a separate coded file which is similar to the way the EPA's NEDS area and gridding systems work.

Question: You are going to have single gas stations as point sources?

Bradley: In some cases. The local districts have been involved in trying to separately treat the gas stations because of vapor recovery requirements. They have them on permits and so on. Where that information exists already, they can be treated as point sources. Where this information does not exist, and there are a number of air basins in California where the vapor recovery regulations are not in effect the problems may not be

Bradley: (con't) significant enough that they will be implemented there; then, they will be treated as area sources. So, the split is partially a local district option at this point.

Comment: The reason I bring this up, I think, is quite important. We have found out in Northern Virginia, where I come from, that even in view of the very small piece of geography, that there are somewhere around 600 gas stations and these are bought and sold monthly. Trying to keep up a point source of inventory on gasoline service stations is a big job. I don't think you can punch these things out as point sources and look at it once a year and have an up-to-date file. It isn't going to be updated. There's going to be something like a 10% turnover. It would be quite a job keeping the file up to data as it is with any point source. Remember, you are dealing with a lot of them. I've got 500 of them in one little third of a city. Think what you've got in Los Angeles!

CONDENSED DISCUSSION

Bradley: Well, the way things have operated in California, in consistence with the EPA requirements, it has been mandatory that data on sources greater than 25 tons per year of any single pollutant be put into the EIS system, and then there have been options below the 25 tons per year. The area sources are generally below that and then it's an option. There is an inner range in there where some sources could be thrown either way dependent upon the effort that is involved with the district needs. Where a district has gone to the effort of getting the detailed information and doing it on a point basis we are very happy to include that in the data base.

Question: The emissions booklet you referred to seems facinating. I would like to know how often you would update this. Is this monthly, yearly, or is it updated when needed?

Bradley: The system is set up so it could handle information on an inventory year basis, so we would plan to update it more than once a year. Our goal is to update it every year or at least every other year. Whether or not we can achieve that, I'm not sure.

CONDENSED DISCUSSION

Question: Do you know right now how many level one segments and level two segments you have?

Bradley: No, we don't. We have somewhere around 55-60 major categories. However, not all of these are utilized in every county and we have 58 counties in California, so we are expecting to develop quite a bit of information.

Question: Has anyone made any manpower estimates on the number of engineers, technicians, planners, programmers, and keypunchers you need for this system?

Bradley: We normally set aside about 4 1/2 people at the State level to cover about half of the source categories. We expect that the major effort will be in the first year in getting the information into the system. In future years, it becomes more of a maintenance and you don't have to recreate the file. You can work with the changes. Simultaneously, we have a data processing feasibility study underway. We will be shaking the system down this year and have a better idea at the end of the year on these refinements.

CONDENSED DISCUSSION

Question: Is it clear in your mind, now, how you will go about obtaining information year after year? Is it likely you will use questionnaires, field surveys, inventory just a sample of the total source category population, or what?

Bradley: I think it will depend on the source category itself in what is appropriate. I expect that if it becomes necessary to do surveys, the surveys will not necessarily be done every year. It depends on how likely the information it to change by a significant amount from one year to the next. In some cases, there are already reporting mechanisms in place. For example; there are existing records of pesticide usage in California. There is some question as to how much of the pesticides are covered, but there is already a reporting mechanism set up within the department of agriculture in California to handle pesticide application. As we are going through each of the source categories, we are looking for similar ongoing reporting systems which could be utilized.

CONDENSED DISCUSSION

Question: This confidence rating that you are going to give the emission factors--could you elaborate on that and where it is going to come from?

Bradley: I think as a start, we wanted to get some kind of representation of confidence rating. We will probably use something like the old EPA (AP-42). It is a five class code right now. As we get a chance to get some experience with the information, we hope to be able to have a more refined method of handling confidence, in say two to three years from now.

Question: Do you have other groups who will support this system at a local level?

Bradley: Yes, the requests have already gone out to each of the local air pollution control districts for about hald of the categories. We have asked them to be working up information in a general form. Some of our State staff will be involved in taking the information we get from the districts and fitting it into the data system. It is a little unclear how much local effort will be involved. It could be on the order of three or four person years per district, possibly

CONDENSED DISCUSSION

Bradley: (con't) one. We are talking about a fairly big State in California with a lot of sources. In the EIS point source system, we now have about 30,000 entries, that process level entries, in the EIS system covering the whole State.

MARYLAND SPECIAL FACTORS AND INVENTORY TECHNIQUES

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Introduction

The compilation of any emission inventory requires that the scope of the inventory be determined, the data sources ascertained and contacted, and the results verified and reported. Since the manpower requirements and peripheral expenses for any inventory are directly proportional to the scope, accuracy and timeliness desired, an initial workplan delineating these points should be laid out before work begins.

Each of the three major classes of sources, (natural, mobile and stationary) has its own problems and requirements for quantification; the inclusion or exclusion of any source class or subclass must then be carefully examined. Inclusion of a source class with minimal definition as to quantifiable emissions may "cost" significantly more than the maximum contribution to the total inventory is worth.

A second factor which will determine total effort and expense is the possible repetition of the inventory and/or its inclusion into other such reports. If an inventory is to be updated periodically or used as the basis for further inventories/reports, the possibility and expense of computerized operations should be carefully examined. Continuing inventories, unless of a very general nature, are usually best computerized. Special interest inventories such as fugitive dust sources, vapor recovery on service station facilities, toxic and hazardous materials, or photochemically reactive organics may be hand compiled, but usually are more easily used if stored in some type of electronic data process facility.

Maryland's Emission Inventory System

The Maryland Emission Inventory System consists primarily of a Master Tape file of registered sources, backed by several filing cabinets of data input forms. The Master Tape contains data on individual equipment capable of emitting any criteria pollutant. Each record of the nearly 15,000 on file is individually identified and coded for its specific county, premise, type of equipment, fuels used and emissions rates. Each of the 194 characters on each record may be used in combination with others to produce requested reports.

This Master Tape is updated semi-annually in January and July. Some fifteen standard reports are produced routinely with each update; non-standard or special reports are produced upon request at a contract facility. Copies of these reports, both in standard and special formats, are sent to all local jurisdictions and to each Division of the Bureau of Air Quality and Noise Control for review and use.

The Registration Survey System (RSS), the formal title for these standard reports, was developed over a three year period from 1969 to 1971; changes in format and content occur at regular intervals as needs and requirements change. The RSS began as a registration file on those stationary sources above certain minimum sizes or of specified equipment types. Maryland's system required all incinerators, process and manufacturing equipment (unless specifically exempted) and fuel burning equipment above home heating input sizes to register on forms provided by the Bureau. Initial efforts to have the owners of all affected sources obtain and complete the forms were partially successful; most major emitters, once contacted, completed the forms within a year.

As the number of completed forms increased, some type of computerization became necessary; the forms were initially modified to be used directly as keypunch sheets as well as data input forms and a year's effort in programming was initiated. After two full revisions, the system became operational in 1971; those who have taken the EPA course on registration and inventories in the early 1970's at Research Triangle Park have seen the second modification to the keypunch forms.

In order to maintain the Master Tape in a current condition, changes to the file due to additional construction, equipment modification or replacement, or the cessation of operations, are routinely included. The construction of any registerable sources without an approved Permit to Construct is a violation of the Air Quality Control Regulations and subjects a violator to possible civil penalties. At the present time, each of the building permit offices in each of the local jurisdictions requires that the local air quality control agency sign off on any construction permit before an applicant can obtain a building permit. Applicants for such permits must complete a Permit to Construct application and obtain an approval from the central office prior to the local agency's approval of the building permit application. A minimum number of small pieces of equipment evade this system through error or oversight.

When a piece of equipment is eliminated or a business ceases operation, a local agency inspector completes and sends to the central office a notice of this occurrence. A standardized format computer card is made which can delete either an individual piece of equipment or an entire premise.

Modifications to existing equipment or changes in fuels consumption, control equipment, etc., which outdate an existing registration, require that the owner or operator re-register with the Bureau. This source initiated re-registration is theoretically the most efficient method for keeping the file current. In practice, most "modified" sources are re-registered due to field or premise inspections performed by State or local personnel for other purposes.

These other purposes include the required annual inspections for a Permit to Operate required for major emission points. Specific types or sizes of various process, incineration and fuel burning equipment are required to obtain an initial Permit to Operate and an annual renewal. Such a Permit to Operate cannot be granted until a detailed field inspection and registration file verification for that piece of equipment have been completed.

In spite of a determined effort to obtain complete initial coverage in the late 1960's-early 1970's, some equipment was overlooked, erroneously exempted, or incorrectly registered. Some equipment was built, modified, switched fuels or eliminated without proper notification. In order to cover these omissions and errors, a program was initiated to check all registration data on a minimum of every three years. As each "error" is discovered, new records are created replacing the existing file. This new Master Tape file then becomes the source of data for the standard reports, while the old version is stored for possible comparison purposes.

This program of verification has been aided to a great degree by other compliance activities such as the rotary cup burner phase-out (Regulation 10.03.38, .39.06) and the fugitive dust source determination. These programs used the RSS printout as the basis for initially selecting locations. As each location was examined for its particular project needs, concurrent review of the existing registration file was conducted; missed or erroneous registerable equipment was noted and changes were sent through the system as regular alterations to the RSS file.

The soon-to-be-formalized Compliance Data System will also generate some changes to the RSS file in that field inspections for complaints, regular compliance activity inspections, etc., will generate some changes in the RSS. The changes will modify the Master Tape file as needed and be used to as a portion of the registration verification/compliance assurance program.

The RSS system, then, is represented by the algorithym shown in Figure 1. As noted, a new tape file is created at the time each group of reports are produced. This tape is used for all special request listings, printouts, etc., for such programs as the rotary cup operation, compliance assurance operation, etc.

None of the special inventory results are included in the Master Tape file; the file format is not broad enough to encompass these special emission values. All particulate matter, for instance, is labeled and grouped as particulate, whether it is a metal, mineral, liquid emission, etc. Hydrocarbons are grouped as total hydrocarbons, including methane, non-reactive material and those of most interest in photochemical smog investigations.

Special Inventory of Photochemically Reactive Organic Materials

The special inventory of photochemically reactive organic materials was conducted by the Division of Program Planning and Analysis as part of an effort to more accurately characterize the Baltimore region's "smog" problem. A total inventory of organic emissions for the region would include those components from natural, mobile and stationary sources.

Natural sources include plants, primarily trees. Emission "factors" are available for certain types and densities of tree growth; in rural, heavily forested areas, this emission source can be the major source of reactive organic emissions. Estimates for the Baltimore AQCR indicate that natural emissions are only about 7% of the total hydrocarbon emissions in the region, and are located primarily in the rural portions of the AQCR. The degree of uncertainties regarding the emission factors is so great that inclusion in the inventory was considered to be unwise. As better factors are developed, natural emissions will be included.

Mobile emissions are those from automobiles, trucks, buses, trains, planes, ships, snowmobiles, mopeds, etc. Those familiar with the compilation of inventories know the difficulties inherent in attempting to locate, quantify and verify the emissions from such sources. Individual units contribute such small amounts that these "sources" must be handled on a group basis spread over an area of concern.

Several possibilities exist for such source classes including complex traffic counting and computer modelling, wide-area surveys, countywide estimation, and national average estimates. The previous efforts to quantify hydrocarbon emissions for the State Implementation Plan required little detail; total hydrocarbon emission from the mobile and stationary sources was estimated from available data with little additional effort used to further expand or improve the inventory. Since the "Appendix J" methodology was concerned only with the total non-methane hydrocarbon emissions, little effort was expended to obtain a species breakdown of the emissions. Since the SIP work was aimed at percentage reductions, this amount of detail was more than sufficient.

Mobile source modelling data are also available for the urbanized portions of the Baltimore region from the Baltimore Regional Planning Council. RPC has conducted a detailed work trip-home location survey, coupled with traffic counts over long periods of time. Efforts to define peak period or peak hour emissions, workday versus weekend rates, etc., were less than successful. Average daily workday emission values were subsequently used for RPC modelling purposes with factors applied for other periods. While excellent for the intended purpose, the RPC model could not adequately handle the diurnal variations of organic emissions and will probably best be used for carbon monoxide modelling where photochemical conversion of the emission is not a factor.

The remaining sources of mobile emission data are those of fuel sales/use and registered vehicles. Fuel use figures are readily available in a statewide, all uses basis. By combining registered vehicles data and EPA emission factors with Maryland vehicle age-use information, the average vehicle and its expected annual emission rate can be determined. Cross-checking these expected Maryland emissions with annual average national data on mileage/usage/emissions usually yields figures of comparable magnitude. Based upon these estimates, it is possible to breakdown the mass emission rates into organic class. The paucity of gas chromatographic analysis of exhaust from a wide variety of automobiles and other mobile sources requires that estimated quantities be used. Some published reports which yield significant information concerning the species specific emissions from these sources are available, primarily those of Black[1] and Lonneman[2].

Two potentially significant sources exist which do not fall neatly into either mobile or stationary source classes. These are natural gas transmission lines and asphalt cut-back solvents. Natural gas contains a small amount of reactive hydrocarbons; leakage at joints, etc., and the "lost" footage not known to have been used allows this component to be released directly into the atmosphere. The utility maintains accurate records on the estimated volume of this gas and, when contacted for the general inventory, provides the value used for the "evaporative natural gas" component of the inventory. Using the average composition of natural gas, it is possible to estimate the class breakdown of this emission.

Asphalt cut-back solvents are those volatile materials used in paving operations to maintain the asphalt in a fluid condition during application. The existence of this large "stationary" but moving source was "discovered" only recently. A new project was developed to determine the potential for control of emissions from this non-specific major source. The results of this project were added to the inventory, providing the mass amount of solvent used. However, neither the time breakdown or usage and composition of the emission have been determined. This will require a considerable effort and plans are presently being developed to handle this task.

The last group of sources of interest is stationary sources. Such sources range from individual home heating units to massive sheet metal coating process lines. As previously indicated, the scope and timeliness of any inventory are directly relateable to the manpower expended. Since small fuel burning sources, open burning or incineration, and small process operations such as drycleaning contribute little on an individual unit basis, these are usually handled on a class/group basis.

Census estimates of home heating, refuse generation and drycleaning requirements are usually sufficient. The total hydrocarbon emission estimated for each group is obtained, the organic class breakdown was determined where possible, and results added to the inventory as small stationary sources. Large municipal incinerators, utility power plants, or large process boilers emit significant amounts of organic emissions. For those of 25 tons per year or more total organic emissions, an individually calculated value of organic class breakdown was determined and added to the inventory. These figures were calculated from existing registration data and AP-42 emission factors without source contact. Literature information on the organic class breakdown was used to determine the species information.

Once incineration and fuel burning components have been determined, the only remaining stationary component lies in the process equipment area. As mentioned small units such as drycleaners, paint spray booths, etc., are most easily handled as classes with little or no loss in accuracy. Sources of 25 tons per year or more, however, need individual attention due to their size and varied species of emission.

Fuel storage or transfer sites (gasoline terminals) were inventoried on the basis of on-file data. Gallons handled, control equipment and its efficiency, and storage container variables were factored into the determinations made and the resulting organic emissions added to the inventory. The source of information for the organic class analysis was a report of gas chromatographic sampling of a gasoline terminal. While gasoline is extremely varied in composition, the bulk of the emission is the same for all brands of gasoline. The use of these test data were deemed representative of all emissions from the gasoline terminals.

The remaining large sources, those of 25 tons per year or more hydrocarbon emission were individually contacted by questionnaires and the results added to the inventory as each was determined. This size range was chosen since it represented the bulk of the registered sources of organic emissions and did not place an unreasonable burden on the existing resources available to complete the project.

The first step was to develop a list of the sources which would be affected by this inventory from the existing RSS printout. The sources which were of prime concern were processing sources, since the compositional variation within this category could be expected to be the greatest. This list of sources was then used for the second step of the process, developing a special inventory form which could be sent to the affected sources where the appropriate information could be supplied.

This special form solicited information regarding the operation schedule of the source and the composition of the emissions. The specific questions regarding operating schedule were number of shifts per day, number of operating days per week, number of operating days per year and the percent of yearly operating hours by month.

Other information regarding operating schedules included percent of weekly emissions by day of the week. This information was requested in order to obtain as much information as possible regarding operational characteristics of the source. The second set of questions were about the composition of the organic emissions, including the average hourly emissions of aldehydes, aliphatics, aromatics and olefins for the base year 1975. An additional question, relating to process emissions of oxides of nitrogen was added since oxides of nitrogen are also an important part of the photochemical oxidant formation process.

These questionnaires were sent to the RSS list sources together with a cover letter requesting that the sources complete and return the enclosed form within 60 days. The letter also informed sources that they would be contacted by the Bureau engineer responsible for their premise to aid them in completing the form. An individual was also named in the letter and the source informed that this person would be available at any time to answer any questions regarding the type of information requested.

The initial response from the affected sources was usually in the form of a telephone call requesting more details concerning the questionnaires. It also became obvious that many sources were not sure of the chemical composition of their emissions. It was, therefore, necessary to provide guidance to the sources concerning the composition of their emissions. Since the EPA emission factors provide estimates of the mass emission rate from sources but little or no information concerning composition, it was necessary to use other data sources such as the laboratories or technical centers of the affected sources, or the OSHA Material Safety Data Sheet. These sheets provide valuable composition information concerning the materials used in industrial plants. If neither of these sources is available, the use of professional judgement is necessary.

The completed forms were returned to the Bureau for analysis, checked for completeness and the total mass amount of emissions in the four categories compared to the total organic emission calculated using the EPA emission factors. This check was used to verify the reasonableness of the calculations made by the industrial sources. In many cases, the sources were unable to complete the form due to a lack of knowledge of organic chemistry. Bureau personnel were supplied with the OSHA data sheets and the operating schedule for the sources. Using this information in conjunction with the emission calculations made by Bureau engineers, it was possible to develop an organic class breakdown of the emissions from the industrial sources for the total list of sources. In case of questions regarding the data, return calls or meetings were held with the sources in order to correct the emissions estimates.

Following the review of the questionnaires, it was possible to compile the special emissions inventory for the major sources. This information was added to information already available for the other source categories, completing the special inventory.

Application to State Implementation Plan

The main purpose of the Maryland special organic emissions inventory was to improve the existing modelling techniques available to project future levels of photochemical oxidants and corresponding control requirements. The past model used in State Implementation Plan development for photochemical oxidants was "Appendix J", a simplified technique which stated that oxidant was strictly a function of total non-methane hydrocarbon emissions. Since the promulgation of this technique, many questions have been raised concerning this approach. It now appears that "Appendix J" methodology is not valid for projecting photochemical oxidant control requirements. A number of alternatives have been proposed to the "Appendix J" approach, including the smog chamber diagram approach outlined by Dimitriades[3] and Dodge[4]. The Bureau considers this approach to be a reasonable alternative to either the expensive and resource intensive photochemical air quality simulation models and/or the overly simplistic linear rollback approach, and is preparing the inputs necessary to utilize this approach.

One approach in which the Bureau has invested time and resources is the Hect, Seinfeld and Dodge[5] chemical kinetic model. This is a 37 step lumped chemical kinetic model which simulates the production of photochemical smog. The lumping involves the use of four organic classes of compounds rather than specific species, including aldehydes, aliphatics, aromatics and olefins. This mechanism can then be used to generate a smog chamber diagram. The usefulness of the Bureau's special organic emission inventory is in the development of the smog chamber diagram which would simulate the behavior of a smog chamber which had been charged with organic compounds with the composition of the Baltimore atmosphere. To this end, the University of Maryland, Department of Chemical Engineering has completed work on the computer program to solve the kinetic equations. Additional work includes two smog chamber diagrams developed using this mechanism. The basic data on the organic composition i.e., class breakdown, came from an ambient monitoring study completed in 1976 for Washington, D.C. Although the study did not do a complete organic analysis, the data did give the Bureau an idea of what to expect from an organic class breakdown. The Bureau's special organic inventory will be used to develop a variety of diagrams for Baltimore.

The second use the inventory will have is related to the special summer study involving species specific organic compound monitoring which is being conducted this summer in Baltimore by consultants to the Bureau. The monitoring will be attempting to characterize the organic composition of the Baltimore atmosphere in the C_2 to C_{10} range, based upon 6-9 a.m. time period. The purpose of the monitoring program is to give the Bureau a reliable measure of the total organic concentration in the ambient atmosphere and the ratio of organic material to NOx. Since species specific monitoring is the only method presently available to deliver this type of information, it is being utilized. The information gained from this ambient program can be compared to the information generated by the special organic emissions inventory and the quality of the emissions inventory can be evaluated/compared to the actual monitored data. Hopefully, the data will confirm the inventory information.

This attempt at developing an organic class specific inventory is the Bureau's first attempt at generating this type of information. Some of the problems encountered have been successfully solved, while others have not been satisfactorily answered. The biggest, basic problem encounterd is the lack of information regarding the composition of emissions from major classes of sources. Estimates have been necessary for many of the categories. Additionally, questions regarding the reliability of EPA emission factor estimator are still open to question. However, the need for species specific information will assume greater importance in the future as photochemical oxidant modelling techniques become more sophisticated. The effort that is being expended at the present time will be useful in the future. The Bureau feels that the sooner the effort is expended to develop this type of information, the sooner the inventory will become reliable.

METROPOLITAN BALTIMORE SPECIAL INVENTORY*
HYDROCARBON EMISSIONS ACCORDING TO ORGANIC CLASS
(in pounds per hour 6 - 9 a.m.**)

	Aldehydes	Aliphatics	Aromatics	Olefins
Electrical Utility	36	53	0	0
Heating				
Industrial	0	0	0	0
Residential	0	0	0	0
Commercial	0	0	0	0
Industrial Process	133	2,071	3,022	448
Mobile Sources				
Autos	2,164	20,396	6,738	9,010
All Others	736	5,412	1,645	2,569
Refuse Disposal	9	7	0	6
Gasoline Storage & Handling	0	2,003	38	489
Miscellaneous	23	224	86	94
TOTAL	3,101	30,166	11,529	12,616

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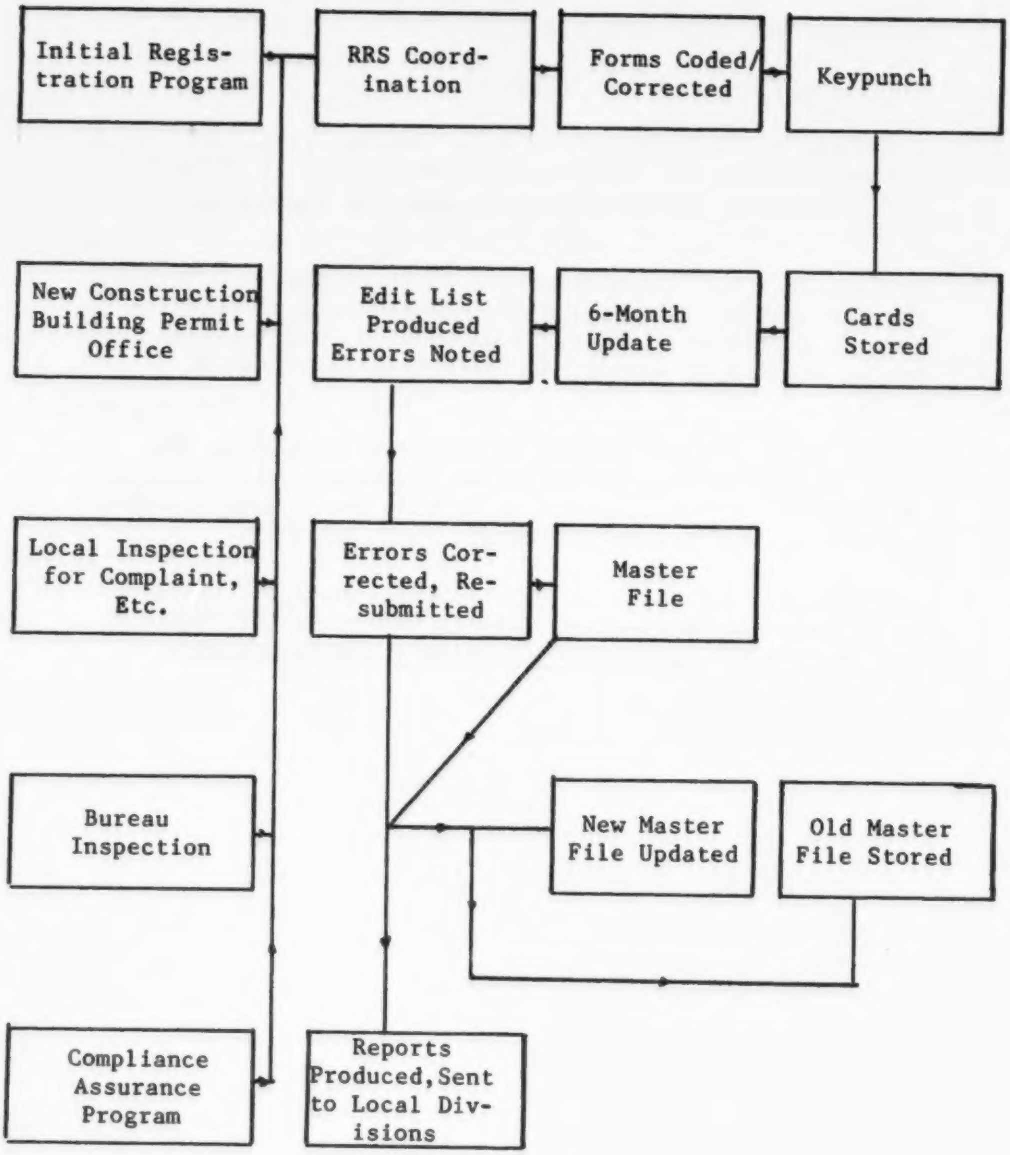
*Preliminary draft subject to verification.

**Average weekday in summer.

HYDROCARBONS - TONS/YEAR

			COUNTY				
	Anne Arundel	Baltimore	Carroll	Harford	Howard	Balto. City	Area III
Electric Utility	369	776	---	83	---	229	1,457
Industry							
Process	6,370	16,634	206	269	187	16,151	39,817
Heating	11	788	21	3	10	195	1,028
Comfort Heating							
Residential	169	141	107	78	24	133	652
Commercial	3	6	---	---	---	27	36
Institutional	33	30	7	15	---	24	109
Mobile Sources							
Autos	16,580	34,641	3,876	6,203	5,238	25,443	91,981
All Others	8,447	8,869	2,314	2,542	1,563	7,675	31,410
Refuse Disposal	---	---	---	---	---	281	281
Gasoline Storage Handling	1,470	2,321	1,043	643	370	5,338	11,185
Miscellaneous	235	440	84	140	103	867	1,869
TOTAL EMISSIONS	33,687	64,646	7,658	9,976	7,495	56,363	179,825

FIGURE 1


Initial Registration Program
RRS Coordination
Forms Coded/Corrected
Keypunch
New Construction Building Permit Office
Edit List Produced Errors Noted
6-Month Update
Cards Stored
Local Inspection for Complaint, Etc.
Errors Corrected, Resubmitted
Master File
Bureau Inspection
New Master File Updated
Old Master File Stored
Compliance Assurance Program
Reports Produced, Sent to Local Divisions

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PANEL DISCUSSION OF INVENTORY METHODOLOGY PROCEDURES AND APPLICATIONS TO OXIDANT CONTROL

A panel discussion of various current problems in emission inventory and factor technology is condensed on the following pages. Panel members were James Southerland, Moderator, Patrich Bartosh, (Radian Corp.), Bradley Grem (U.S. Air Force), Lew Hickman, (EPA Region II), William Piske (TRW Inc.), Ed Carter (State of Maryland), Rich Bradley (California Air Resources Board), David Henderson (EPA Region IX) and Lloyd Hedgepeth (EPA Office of Air Quality Planning and Standards).

CONDENSED DISCUSSION

Question: I wonder if the panel members might want to discuss their feelings about the need for some sort of a general emission inventory handbook on the order of the rapid survey technique but more current? I have found in trying to discuss with people in our region, how to go about doing an emission inventory. I haven't really been able to give them a document that is fairly simple and up-to-date.

Carter: My experience has been that there is really no cut and dry method for doing an emission inventory. The rapid survey technique pretty well says it. It is mostly a matter of finding out who to contact. Once you find out who the guy is who just happens to know what all the information you are looking for is, it is a matter of writing it down. It may take you several weeks to finally get a hold of him but its just a matter of dog work getting hold of the right location.

CONDENSED DISCUSSION

Moderator: I would say also from my point of view, that as Pat Bartosh mentioned this morning in the document that we have in preparation for organics; when we sent this out for review comments with the regions and so forth, one of the comments that we kept getting over and over was the document is asking for guidance in itself. In otherwords, the comment was it is begging for a decision for what you do in various situations. They way we addressed the situation was that we did not feel we could identify what you should do under unique situations in all cases and we tried to develop a decision tree route. We try to point out that these are the routes you can take in various areas and under various situations. We try to point out the kinds of things you need to consider in order to develop your own plan and your own set of alternatives for

Moderator: (Con't) the emission inventory. I think this is the same kind of comment that Ed Carter had here. In many cases people are asking "what do we do exactly". There are cases where we can't be aware of all the circumstances that would be required to be considered. What we would say in one set of circumstances may not apply in another. So it has to be pretty much individually worked out to meet the unique local situation.

Question: What are the prospects for modification of EIS to handle reactive hydrocarbons?

Hedgepeth: From EIS point of view, as far as the number of pollutants, the way this system is designed it will handle right now up to 16 different pollutants. If you want to include various hydrocarbons, fine. You just give them an ID and include them. It is not limited to the five criteria pollutants. We designed it so it would handle as delivered up to 16. If you want

CONDENSED DISCUSSION

Hedgepeth: (Con't) to handle more than 16 pollutants, look at the documentation that goes with the system. We tell you exactly how to expand that or extend it beyond 16 pollutants if you like. So the inventory or the EIS emissions inventory permit and registration system is really not oriented toward just SO_2 or particulates. It's really oriented toward any emissions data for any pollutant that you would like.

Comment: We have not gotten acceptable output for our use from the system in our state. Let's get specific. Take a bulk terminal. Now you've got a whole series of different types of emissions and you've got floating roof factors. You've got fixed roof factors. You've got through put for various products, etc. The basic data hasn't been punched to give you the full spread. In some cases, the data cards the state has show nothing, but name. You don't have anything on the loading factors. I'm not trying to critize the system. I'm

CONDENSED DISCUSSION

Comment: (Con't) just suggesting that its a tremendous job trying to get the data all spread out and get the sheets all laid out, etc. for pure hydrocarbon sources and that they simply have not gotten around to this. It's been used principally as a particulate and SO_2 system which is pretty good for handling fuel products. What you have primarily is fuel burning. When you get into a whole raft of different emissions factors and running different sheets for each emission point in a purely hydrocarbon type source, it's pretty complex. Our system hasn't been straightened out enough to make it useful. Therefore, we are in a panic situation right now. Also this looks to be the only thing we are going to be able to use for the next year or so.

Hedgepeth: What you are saying, then is that the basic problem is your inventory itself. It is not up-to-date. It needs to be

CONDENSED DISCUSSION

Hedgepeth: (Cor't) expanded beyond what it is to incorporate hydrocarbons or get more specific on the particular given installation.

Comment: The point source data sheets have all got to be redone from a hydrocarbons point of view. This is my point.

Hedgepeth: You are really saying though that your emissions inventory file that you have needs to be upgraded from the view point of hydrocarbons.

Comment: Right.

Hedgepeth: And as far as the emissions inventory system itself goes, it can handle it. The large problems in any data handling system are actually building the initial file, and in keeping that file up-to-date. That is where a lot of manpower and hard work comes; building that file initially and keeping it up-to-date.

Question: We have heard a lot of discussions on different types of emissions inventories, area sources and point sources, I would like to know what this panel would think about further defining what a point source

CONDENSED DISCUSSION

Question: (Con't) would be in terms of "type" of source and what an area source would be in terms of "type" of source instead of an emissions cutoff say at 25 tons? How should we go in the future? We may go below 25 tons - we may go down to 10 tons. How you define what a point is or what a facility is may predetermine how you are going to catagorize that source, how you are going to update that inventory and how you are going to classify it. Any comments?

Bradley: We have been trying to maintain a little flexibility in California on that. Maybe part of the answer depends on how much resources you have to put into a particular source category. Some areas in California have inventoried each gas station as a point source. We've not prevented that from happening. In other areas they are inventoried as area source.

CONDENSED DISCUSSION

Bradley: (Con't) Part of the distinction between the two areas is that one area was a non attainment area. There is a much greater need for the information and for doing some photochemical modeling. The other areas are very rural and don't have the same air pollution problems. To come out with a hard and fast rule, I think, always poses a problem. I'm not sure I have a better definition for you. I think the experience of the staffs working at trying to assess the emissions for the source catagory provide the best basis to make the decision on what is appropriate way to handle it. That, is in a way, passing the buck.

Moderator: Basically, in kind of an academic sense, you could eliminate area sources entirely if you looked at each individual source of air pollution individually. Then these would become point sources by the academic definition. It all becomes a matter of what you are going to do and how much is

CONDENSED DISCUSSION

Moderator: (Con't) it going to cost and how much you have to do the job with. The resource restraint is generally a big item and the reporting requirements for instance may be what determines the practical or used definition of a point source. It varies from one situation to another. In one local area you may have ten-one-thousand ton emiters and practically no small emiters. In another case you may have 90% of your emissions from area sources and have no large sources. It takes an analysis of your own situation to see what it is that it takes to define where does it all come from?"

Comment: I'd like to amplify that if I may. I agree with what you have said and I think it goes a little bit further than just trying to think of writing a standard rule saying all gas stations will be area or point, or that all dry cleaning plants will be area sources. It really depends on such things

CONDENSED DISCUSSION

Comment: (Con't) as you may wish to address about. For example number one is how fast do the sources change ownership? How fast do they come in and out of your files? I mentioned earlier this afternoon, we found that gas stations are coming in and out at a furious rate. If they are in a point source file , we are unlikely to keep the point source file up-to-date. That's the argument of not putting them into the point source file. The way you get the true information may dictate that it be dealt with as an area source rather than a point source. My answer to the question would be that you examine each source locally because there are great differences around the country and examine which is the most practical, simple, economical more efficient way to do it - make a decision rather than using some arbitury method. I think generally speaking the one ton, ten ton, twenty five

CONDENSED DISCUSSION

Comment: (Con't) ton or hundred ton whatever cut off may have been developed for one purpose but may be applied across the board just because that is what everybody else does. What I am trying to say is that there may or may not be reason in an individual case for the using the same specific cutoff.

Question: I have a question for Dave. I think Dave you indicated - correct me if I'm wrong - that you use 85% evaporation for waste lubricating oil.

Henderson: Yes, for weed oil applied on agricultural fields.

Question: I wonder if that is a valid assumption. What's your basis for that if I may ask?

Henderson: We have done some limited testing. We feel that if you take a sample to the laboratory for a research time period, come back and determine how much it evaporates, then you can assume that a similar situation exists in the field. The condition that was given to me by the

CONDENSED DISCUSSION

Henderson: (Con't) person at the air pollution control district was that it has to go somewhere.

Comment: Well the soil bacteria will eat these oils up. That's one means of disposal of solid waste.

Henderson: That may be true but we can't quantify it right now.

Are there some additional questions?

Question: One problem I see we run into all the time is confidentialty. Companies like to keep some information confidential. It's difficult for the public to ascertain what you have done and it is difficult for another person to reconstruct years later and with confidential data. I would like to know what the panel has found out about this in their activities and their studies and if anything what they are doing about it?

Moderator: Maybe I could get a comment from state and from regional representative on this.

CONDENSED DISCUSSION

Comment: Our Attorney General indicated that emissions data is not confidential so we can use at any stage we want. Process information which may lead to disclosing trade secrets etc., has to be kept confidential. We have only run into two cases where there was any real difficulty and one of them went to court and they found that they did have to give us the information. I agree that if you try to redo a study three years later and the information the fellow used is not available, you have to use your own information and you can get a wide variation from the same companies. It's something you just try to work around as much as you can. It doesn't help much; we all run into the same problem.

Comment: I know that Texas Air Control Board had some problems in this area when they first sent out their questionaires a few years back. One thing they had on the questionaire

CONDENSED DISCUSSION

Comment: (Con't) was it said "mark this box if you want to keep your data confidential". Well everybody marked the box. So the next time they did it they said if you want to keep your data confidential send us a letter or some information telling why and there was a tremendous difference. Then they had the board to review these letters to determine whether or not they could really keep this information confidential or if it was a trade secret type agreement. Even with the tremendous number of sources you have in the sate of Texas they have fairly well eliminated that problem to the best of my knowledge by making people actually come forth and prove that they need to keep it secret. So this is the only way I know you can get around this problem other than where someone has made a legal ruling on it.

Bradley: California emission data are not confidential but process rate data may be confidential. At the present time there is a procedure set up where a company can claim it is confidential information and put a supporting letter in the files either at the district level or the state level. Generally we have had cooperation from the companies in providing the process information. Recently EPA has proposed to change the classification to confidentiality as I understand and process rate would become non-confidential and considered emission data under the proposal that was in the Federal Registar around June or July of this year. And as I understand the field that was being considered as confidential is percent space heat which didn't make any sense when we read it. I'd be interested in some comments from EPA if anybody knows something about the basis behind that proposal or whether or not that proposal is actually likely to be implemented.

Moderator: Here is Chuck Mann, I think he can comment on this.

CONDENSED DISCUSSION

Mann: I am with the National Data Branch of EPA at Research Triangle Park here. The notice that I believe you were referring to was the July 1, 1977 Federal Register which was issued by the Office of General Council in Washington, D. C. and what they proposed to do was to say that all items in NEDS were emissions data. They wanted to make a blanket determination as to whether or not all the items NEDS point source form were confidential or were not confidential. What they did was, by a process of deduction, go through and list all of the items in NEDS and say that these were all basically emissions data. They did define the annual process rate as part of the emissions data on the grounds that the information is needed in order to calculate annual emission estimates. I realize that there are various state laws that conflict with that general provision. Some sort of resolution will have to be made with regard to that point. Basically, there are only three items in the NEDS file

Mann: (Con't) that General Council was asking for comments on as to whether or not they could be confidential. These are items they say are not emissions data or not generally available from other references or administrative codes. Those three items are the boiler capacities, the maximum design rate for processes and the percent space heat. I would agree that for percent space heat, it is hard to believe how that could be confidential, but the reason that it is considered in that group is that that information is simply not available apparently from any other source. So the current status of this is that, they allowed to August 15th for comments on this issue and I am not aware as to exactly what comments were received and what the eventual resolution will be but that should be forthcoming.

Moderator: The first time I was ever involved

CONDENSED DISCUSSION

Moderator:(Con't) with emission inventory activity several years ago the standard somewhat humerous line was that when you went to a source and they wouldn't give you any data you would say "well I'll have to estimate your emissions and I estimate high". But maybe with the current developments in trade off and that kind of thing, sources would welcome this sort of thing. This issue of confidentiality has always been a kind of a nemesis It's always been one of those sticky situations. In addition to the Federal REgistar notice of July, there was one of last October which had many, many pages which went into EPA's full philosophy and procedure detail on what is confidential and what has to be done with the data, etc., but many of these things do apply just to data that comes directly from the source to EPA.

Question: A related question to confidentiality is public assess to information. As the systems become more computerized, it

Question:(Con't) would obviously be easier to provide information to anybody. Anyone can find out how his competitors are doing. Does the Federal Government or does anyone have any ideas how you limit the providing of such information? We do it in our State as just a matter of policy to provide information to only those who need it with regards to emissions, with regards to environmental impact statements, with regards to special studies involving environment etc., and not so much for information on activities of competitors and things like that.

Moderator: Well according to the Freedom of Information Act and I'm not a lawyer so I'm not speaking in a legal sense, if data is not confidential anybody can ask for anything whether they need it or not. So the confidentiality again, has to be a basis for that and if the person requesting the information feels that the data has

Moderator:(Con't) been denied him he can bring a suit to get that information. I guess, you know, there has been a lot of cases in other agencies where these kinds of data have been filed for and eventually gotten. I am not aware of any with EPA.

Comment: We have the tendenancy to use the policy that a regularly published report is available free of charge. If that is not sufficient we have files of data forms that you can look at. This usually satisfies most people.

Moderator: Under the Freedom of Information Act Federal agencies are to charge for the cost of filing requests. According to the Freedom of Information Act this can not be used as a way around filling such requests, but it generally is a deterient to anybody asking for a lot of information you know that they woud just like to have for some super ficial reason. It kind of narrows the information requests down to the people who feel

CONDENSED DISCUSSION

Moderator: (con't) that they have good use for the data which I guess is sort of the basis for the Freedom of Information Act.

Henderson: From my point of view, one of the major short comings of the emissions inventory in our region is the lack of hydrocarbon specie data. We've got lots of information on total hydrocarbons. Here today Mr. Carter said that he needs that data and uses that data and the gentlemen from the Air Force says he needs that data and uses that data. When you start checking into it however, you find that you can't get even a good estimate of the exhaust gas analysis from automobiles. It is changing every year. What is the percent methane in automobile exhaust gas from year to year due to additional catalyst convertor equipped cars being on the highway? When you look for composition of gasoline from floating storage tanks, you find it just

Henderson: (con't) doesn't exist. The major oil companies don't have it because they have never needed it. They never had a need for it, so they just never generated it. Diffusion models have anywhere from 15 to 37 chemical reactions and you have to know the composition of the emissions and the chemical reaction rate to put them in your diffusion model to correlate emissions to ambient air quality. If you are not doing diffusion models, I don't see a need for it. But, there is a need for this application and thus far the data.

Comment: Our requirement is for greater resolution than methane is non methane or reactive use non-reactive. We would want to know your number of C3 hydrocarbons, number of aeromatics, number of C4, C5, C6 etc. for the modelers to put into their diffusion model.

CONDENSED DISCUSSION

Moderator: I would like to comment on the comments. I think that we are in agreement that there is a lot of information that is needed. We are pretty ignorant when it comes right down to it on many of these areas. The one thing I would like to just point out from the standpoint of AP-42, is that it is a compilation of data that is available or developed primarily by someone else for various purposes. In a lot of aspects our group ends up being one which collects these concerns or these needs for information and makes a case for them and goes to somebody else and say we need the information or research. It is very time consuming in terms of getting information out to the people who are actually using it on a day to day basis. For example, the data that the EPA automotive groups in Ann Arbor develops on in use vehicles necessarily has to be on vehicles that have been made and are in operation. The Office of Mobile Sources Pollution Control is very sensitive to our

Moderator: (con't) needs and as I understand it, they are developing some plan to expand the nonmethane data base from the automobiles. The data itself is reduced in Ann Arbor and then goes to the Office of Transportation Land Use Policy in Washington who is responsible for the preparation of the motor vehicle or highway vehicle emission factor documentation and guidance. It is then shipped down to OAQPS for our review and incorporation in the AP-42. I am only mentioning this to say how sometimes these things are not as timely as one might imagine to be possible. It's generally a communication situation in a lot of cases as to what is available and what isn't available.

Question: Didn't they have to determine reactivity for the RAPS study? So in terms of St. Louis weren't emission factors broken down by class or reactivity?

Moderator: Yes, as a matter of fact. The responsibility was in our office. There is some information that you would say is new data. The RAPS emission inventory is basically an hourly

Moderator: (con't) emission inventory with species and temporal distribution, etc. Initially in the RAPS, however, the primary concerns were for SO_2 and particulate. So the major part of the resources were devoted to SO_2 and particulate. There were some source tests done for hydrocarbon sources and some species data. A lot of the species data was either taken from the Trijonas work in Los Angeles and some other similar references.

Question: Do you feel that the factors you use in the AP-42 are good enough to use for litigation? I get the feeling they are not all that good for this purpose.

Moderator: I think you are probably true in a lot of cases. A lot of factors are really good and some are not so good. They do need work done on them but they are generally the best available as far as we can determine. We are trying to make the effort to get anything that's better in the document. The litigation question is one I can't really respond to. I think what you are asking is really a legal question which I am not qualified to answer.

HYDROCARBON EMISSIONS FROM HOUSEHOLDS IN NEW YORK AND NEW JERSEY

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Abstract:

An attempt was made to quantify the various gaseous hydrocarbon emissions from household sources in the States of New York and New Jersey. The summaries show that household hydrocarbon emissions may be as high as those from industrial sources. These hydrocarbon emissions may also have toxic effects, affecting persons in the household as well as those outdoors.

Many sources have been covered. These are: aerosol propellants (fluorocarbons), fluorocarbon refrigerants, organic compounds and trade name solvents, household (trade) paints and thinners, household and restaurant cooking, domestic fuel combustion, and cigarette smoking.

The hydrocarbon emissions from household products are, for the most part, directly related to the amounts of products used. Product use data for New York and New Jersey was derived from retail sales data.

Emissions are on a tons per year (TPY) basis and are outlined as follows: Fluorocarbon aerosol emissions are about 20,000 TPY for New York, and about 8,000 TPY for New Jersey. Trade name solvents emissions are about 32,000 TPY for New York and about 13,000 TPY for New Jersey. Total estimated emissions are 120,000 TPY for New York and 50,000 TPY for New Jersey.

Other organic compounds emitted in relative large quantities are propane, iso-butane, methylene chloride, ethanol, acetone,

1, 1, 1 - trichloroethane, isopropyl alcohol and paradichlorobenzene.

Introduction:

The purpose of this study by the U. S. Environmental Protection Agency (EPA) is to estimate the amounts of gaseous hydrocarbons released from household sources in New York and New Jersey. These area sources might be compared with industrial and mobile sources as to tonnages and toxicity. This study was done in conjunction with another hydrocarbon emissions study.[1]

I define household sources as items used or consumed in the household. Hydrocarbon emissions from fuel combustion and restaurant sources have also been included, however.

Hydrocarbon emissions are from evaporative, propellant gas, and thermal decomposition sources. These emissions might have toxic effects as well as possibly being reactive with atmospheric ozone. Thermal decomposition sources are those involving heating or combustion, while evaporative sources are those where there is vaporization of a hydrocarbon, i. e. , paint thinner. Propellant gases are from aerosol items.

Relatively high are emissions from aerosol items. These include shave creams, hair sprays, insecticides, etc. Emissions from the many "regular" packaged products; lotions, medicinals adhesives, floor polishes, etc., are in this same category. Evaporatives from household (trade) paints and thinners, and fluorocarbons from refrigerator units as well as hydrocarbons from fuel combustion and household cooking are also emitted in large tonnages.

What follows are the derived factors for estimating the hydrocarbon emissions. Data for household product hydrocarbons was obtained for the U. S. A. en toto, for 1976, or for a recent year. The amounts of household hydrocarbons used in New York and New Jersey were estimated from the State's percent retail sales in various sales categories,[2] the State's percent population, and other data. Emissions data was derived from the product use data and is on a tons per year (TPY) basis.

Percentages of National Emissions from Evaporative and Propellant Sources

For aerosol propellants, trade name hydrocarbon solvents, and specific organic compounds, except for the organics in trade paints and thinners, the following percentages of national emissions are ascribed to New York and New Jersey:

New York - 7.6%
New Jersey - 3.0%

The above percentages are based on the States' 1972 percent of nationwide sales[2] for drug stores, proprietary stores, and hardware stores. It was assumed that a significant percent of these items are sold at these sales outlets, Except for fluorocarbons which are difficult to incinerate, emissions for New York State were reduced by 2% due to incineration of discarded containers.

Hydrocarbons remaining in unincinerated containers are assumed, in time, to be released to the ambient. Annual emissions, vary somewhat due to changes in item consumption and later date release of unused material.

For fluorocarbon emissions from refrigerator units, the following percentages of nationwide emissions are derived:

New York - 9.8%
New Jersey - 4.6%

The percentages are based on the States' 1972 percent of nationwide sales[2] for household appliance stores.

The above percentages should not change significantly from 1972 to 1976.

For trade paints and thinners the following percentages of national emissions were calculated:

New York - 6.4%
New Jersey - 2.6%

These percentages are based on population and the percent of national trade paint sales[3] for New York, New Jersey and Pennsylvania (13.2%), New York State emissions were reduced by 2% due to incineration of discards.

Emissions Derivation, Thermal Decomposition Sources

Emissions from restaurant and household cooking are based on emissions per unit source and the number of restaurants and households in New York and New Jersey.[4]

Emissions data were obtained from the South Coast Air Quality Management District (Cal.), and the Kansas City (Mo.) Air Pollution Control Office. Emissions from cigarette smoking are in this category and are in relatively small tonnages. They may be significant with regard to indoor inhalation of toxic substances.

Hydrocarbon emissions from domestic fuels combustion are included because of the large amounts of fuels used and poor combustion efficiencies. Definitive hydrocarbon compounds, both saturated and unsaturated, are not specified but are believed to be mainly in the C_2-C_6 range. Emissions data are based on the EPA reports; "Field Emissions from Combustion Equipment for Space Heating",[5] and "Particulate Emissions from Apartment House Boilers and Incinerators".[6] The amounts of fuels used are based on the Mineral Industries Surveys, U.S. Department of Interior, 1975 and the percent of these fuels used for domestic sources is based on a survey made by the City of New York. Anthracite coal combustion is based on U.S. and New York State consumption data. All kerosine used for fuel in New York and New Jersey is assumed to be for domestic use.

National Production, Consumption and Emissions

Emissions for New York and New Jersey in Table I are in tons per year (TPY), along with latest year the data was available. The sources are calssified as follows:

1 - Aerosol Propellants; Hydrocarbon, Fluorocarbon and Methylene Chloride, and Fluorocarbon Refrigerants.

2 - Organic Compounds.

3 - Trade Name Hydrocarbon Solvents*

4 - Trade Paint and Thinner Volatiles.

5 - Cooking, Restaurant and Household; and Cigarette Smoking.

6 - Fuel Combustion.

(1) Aerosols:

(a) Hydrocarbon Propellants:

Applicable hydrocarbon[7] production of propellants for 1976 was 40 x 10^6 gal. Three hydrocarbons are used, and in the following percentages:

Propane	30%
Isobutane	63%
n-Butane	7%

Usage and emissions are increasing at about 19% per year.

(b) Fluorocarbons:

Nationwide fluorocarbon[8] production in 1976 was 910 x 10^6 lbs./yr. Fifty-eight percent (58%) was for aerosol use and forty-two percent (42%) was for refrigerant use.

Aerosol[9] production is as follows:

Fluorocarbon 11 - 244 x 10^6 lbs./yr., Emissions are 100% of production.

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* i. e., Mineral Spirits.

Fluorocarbon 12 - 265 x 10^6 lbs./yr., Emissions are 100% of production.

Fluorocarbon 114 - 21 x 10^6 lbs./yr., Emissions are 100% of production.

Refrigerant[9] production is as follows:

Fluorocarbon 11 - 15 x 10^6 lbs. /yr., Emissions are 45% of production.

Fluorocarbon 12 - 226 x 10^6 lbs. /yr., Emissions are 51% of production.

Fluorocarbon 22 - 137 x 10^6 lbs. /yr., Emissions are 51% of production.

Fluorocarbon 114 - 2 x 10^6 lbs. /yr., Emissions are 51% of production.

Refrigerant fluorocarbon emissions are based on 1976 production and 1972 production and emissions.[10]

The trend in fluorocarbon aerosol emissions is an estimated decrease of 1.8% per year, and the trend in fluorocarbon refrigerant emissions is an estimated increase of 11.3% per year.

(c) Methylene Chloride:

The use of methylene chloride as an aerosol propellant was estimated to be 62 x 10^6 lbs. /yr. (1976). Data from the Dow Chemical Co. was averaged with Faith, Keyes and Clark[11] data.

(2) Organic Compounds

Noted below are the organic compounds used in large quantities in pharmaceuticals, toiletries, insecticides, floor cleaners, etc.

National production data for these compounds, and the percentage used for household items are based on Faith, Keyes and Clarks', Industrial Chemicals.[11] Emissions are listed in Table I. Except for the two percent incineration "loss" for New York State, emissions are assumed to be equal to the amounts used.

(a) Naphthalene:

Production in 1973 was 250 x 10^6 lbs./yr. Emissions are based on the 2% of production used for mothproofing.

(b) Paradichlorobenzene:

Production in 1973 was 75 x 10^6 lbs./yr. Emissions are based on the 50% of production used as a space odorant and the 40% of production used for moth control.

(c) Isopropanol

Production in 1974 was 1.9 x 10^9 lbs./yr. Emissions are based on the 5% of production used in drugs, cosmetics, toiletries, etc.

(d) Acetone:

Production in 1973 was 2 x 10^9 lbs./yr. Emissions are based on the 6% used in pharmaceuticals. Acetone is used in household products including trade paints.

(e) 1, 1, 1 - Trichlorethane

Production in 1974 was 590 x 10^6 lbs./yr. Emissions are based on the 15% used as an aerosol propellant, adhesive solvent, dry cleaner, etc.

(f) Ethanol:

Production in 1974 was 1.74×10^9 lbs./yr. Emissions are based on the 20% of production used in cosmetics and toiletries.

(3) Trade Name Hydrocarbon Solvents:

Many trade name hydrocarbon solvents are used in household cleaner type items; i.e. floor polishes, furniture polishes and rug and upholstry cleaners. These solvents are known as naphthas, Stoddard Solvent, petroleum distillates, etc. They are mixtures of alkanes, olefins, naphthenes and aromatics. Trade paints and thinners also contain these solvents.

The Shell Chemical Co.[12] has developed overall numbers of 1975 consumption of these solvents; 40×10^6 gal./yr. Consumption is increasing at about 4% per year.

The total amount of trade name solvents used would include trade name solvents used in trade paints and thinners. These are discussed below.

(4) Trade Paint and Thinner Volatiles:

National Paint and Coatings Association (NPCA) data for hydrocarbon solvents used nationwide in 1975 in household and traffic paints* was 609×10^6 lbs./yr. Percent solvent composition was also supplied by the NPCA, and emissions of most of these solvents are listed in Table I.

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*Traffic paint is about 6% of the total.

Referring to Table I, please note that acetone, isopropyl alcohol and ethyl alcohol used in trade paints are added to the amounts listed under "Organic Compounds". Trade name solvents are also summed.

(a) Thinner Volatiles:

From data supplied by the NPCA it was estimated that 370 x 10^6 lbs. of solvent thinners were used in the U.S.A. in 1975. Most of the thinners are a mineral spirits type solvents, and emissions are based on 80% of the above being mineral spirits.

(5) Cooking, Restaurant and Household; and Cigarette Smoking:

It was estimated that 0.0033 lbs. of hydrocarbons are emitted per hour of cooking. About 40% of these emissions are aldehydes. Cooking means boiling, frying, baking, etc. The 0.0033 lbs./hr. emission factor is a geometric mean of two values.

It is assumed that cooking is done in households for one composite hour per day, 300 days/year, and restaurants operate an average of five hours/day, 300 days/year.

The number of restaurants in New York and New Jersey in 1973 was obtained from data in the Statistical Abstract of the U.S.A. (1975):

Restaurants, New York - 24,400
Restaurants, New Jersey - 8,570

The number of households in 1973 was also denoted in the Statistical Abstract of the U. S. A. (1975):

New York - 6,198,000
New Jersey - 2,375,000

The numbers of restaurants and households are assumed to be nearly the same for 1976 and emissions are calculated on that basis.

Gaseous hydrocarbon emissions from cigarette smoking are listed in Table I. Particulate hydrocarbons are also released during smoking. These have not been tabulated since these are solids and they would tend to settle or adhere to indoor surfaces. Such particulates are "tar", nicotine, cresols, phenol, pyridine and hydroquinone.[13] The gaseous hydrocarbons released in significant amounts are acetaldehyde, acetone, and hydrogen cyanide. The acetone from cigarettes is totaled with the acetone under "Organic Compounds".

(6) Fuel Combustion:

Gaseous hydrocarbon emissions from domestic fuels combustion are also listed in Table I. Listings are made for each of the major fuels used; natural gas, distillate and residual oils, anthracite coal and kerosene.

For fuel oil and kerosene the hydrocarbon emission factor was set at 5 lbs. /1,000 gal., which is close to the boiler "as is" factor of 5.7 lbs. /1,000 gal. given in aforementioned EPA report, R2-73-084a.[5] In addition, from calculations based on the aforementioned report on particulate emissions from apartment house burners[6] a higher emission factor is indicated that the 1 lb. /1,000 gal. factor denoted in the EPA report, AP-42.[14]

For natural gas and anthracite coal the emission factors were from EPA report AP-42.

Conclusions:

The 120,000 ton per year (TPY) hydrocarbon emission for New York and the 50,000 TPY hydrocarbon emission for New Jersey appear to be a significant fraction of total hydrocarbon emissions. For example, hydrocarbon emissions from industrial sources in New York City and Nassau, Suffolk, Westchester and Rockland Counties, for 1975 were calculated to be 89,000 TPY.[15]

The emissions data in this report may be of use in a toxic substances study.

TABLE I

EMISSIONS HOUSEHOLD SOURCES
TONS PER YEAR (TPY)[1]

Aerosol Propellants and Fluorocarbon Refrigerants	New Jersey	New York	Year
Hydrocarbon Propellants			
Propane	880	2,190	1976
n-Butane	210	520	1976
iso-Butane	1,890	4,690	1976
Total	2,980	7,400	
Fluorocarbons			
Fluorocarbon 11			
Aerosol	3,660	9,270	1976
Refrigerant	160	330	1976
Total	3,820	9,600	
Fluorocarbon 12			
Aerosol	3,980	10,100	1976
Refrigerant	2,650	5,650	1976
Total	6,630	15,750	
Fluorocarbon 22			
Refrigerant (Total)	1,610	3,420	1976

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[1] One, two and three significant figures.

TABLE I (continued)

Fluorocarbons (continued)	New Jersey	New York	Year
Fluorocarbon 114			
Aerosol	320	800	1976
Refrigerant	12	20	1976
Total	332	820	
Total Fluorocarbons	12, 400	29, 600	
Methylene Chloride (Aerosol)	930	2, 310	1976
Organic Compounds			
Napthalene	75	190	1973
Paradichlorobenzene	1, 010	2, 510	1973
Isopropyl Alcohol	1, 480	3, 660	1974
Acetone	1, 880	4, 670	1973
1, 1, 1-Trichloroethane[2]	1, 330	3, 300	1974
Ethanol	5, 280	13, 100	1974
Trade Name Hydrocarbon Solvents[3]	4, 500	11, 200	1976
Components, Trade Paint Volatiles			
Aliphatic hydrocarbons[4]	4, 760	11, 800	1975
Xylene	590	1, 430	1975
Toluene	285	690	1975
Acetone[5]	80	190	1975
Methyl-Ethyl-Ketone	160	380	1975
Ethyl Acetate	190	460	1975

2-Also used as an aerosol propellant.

3-Excluding trade paint aliphatic hydrocarbon and trade paint thinners.

4-Essentially trade name solvents.

TABLE I (continued)

Components, Trade Paint Volatiles (continued)	New Jersey	New York	Year
Butyl Acetate	140	345	1975
Ethylene Glycol	430	1,030	1975
Propylene Glycol	285	690	1975
n-Butyl Alcohol	55	130	1975
Ethyl Alcohol[5]	55	130	1975
Isopropyl Alcohol[5]	50	115	1975
Methyl Iso-Butyl Ketone	15	40	1975
Propyl Acetate	65	150	1975
Total Trade Paint Volatiles[6]	7,910	19,100	
Trade Paint Thinners (Min. Spirits)	3,850	9,290	1975
Total Trade Name Solvents	13,100	32,300	
Restaurant Cooking			
Aldehydes	7	24	1976est
Total	19	60	1976est
Household Cooking			
Aldehydes	710	1,800	1976est
Total	1,200	3,100	1976est

[5] These amounts are added to "Organic Compounds".

[6] Includes unlisted organics.

TABLE I (Continued)

Cigarette Smoking	New Jersey	New York	Year
Acetaldehyde	6	15	1972
Acetone[5]	3	7	1972
Hydrogen Cyanide	5	12	1972
Total	23	56	
Fuel Combustion			
Natural Gas	540	1,360	1975
Distillate Oils (Nos. 1, 2 and 4)	3,770	7,980	1975
Residual Oils (Nos. 5 and 6)	840	3,970	1975
Anthracite Coal	250	370	1975
Kerosine	125	525	1975
Total	5,530	19,200	
Grand Total	50,219	123,304	

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CONDENSED DISCUSSION

Question: Could you clarify your numbers a little bit? Were you talking about all of New York State or all of New Jersey or are you just talking about New York and New Jersey AQCR?

Finfer: This was all of New York State and New Jersey. The numbers I gave. The 130,000 and 50,000.

Question: Do you have any comparison since you did the entire state in this area. Do you have a percentage comparison of how these emissions would compare with all of New York State industrial hydrocarbon as a percentage?

Finfer: Not as yet. We are developing an industrial inventory. Then I will be able to compare it.

Question: You mentioned that the AP-42 emission factor for the oil burners was one fifth of what you used. What was the basis for the difference do you feel?

Finfer: Well, I think it was because of maintenance. I don't know whether AP-42 values were developed with full cognizance of the poor maintenance that exists in a lot of New York domestic fuel combustion. A lot of boilers are operated with clogged nozzels, etc.

HYDROCARBON CARRIER EMISSIONS FROM ATMOSPHERIC DYE BECKS

Presented at the 1977
Environmental Protection Agency
Emission Inventory/Factory Workshop
Raleigh, North Carolina - September 13-15, 1977

By

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Abstract

This study was performed to determine the manner and amount of organic carrier emitted to the atmosphere during the dyeing of polyester fabric in atmosphere dye becks. The information obtained was used as supportive data in an over-all investigation of vegetative damage surrounding the source of emissions. The data obtained indicates that the carrier, biphenyl, is emitted at a rate equal to 42-56% of the initial charge during the dye cycle. This data was used to model the emission with time and extend the model to other carriers commonly used.

Table of Contents

Introduction
Description of Process
Sampling Methods
Discussion and Results
Conclusion

List of Figures

Figure 1 Atmospheric Dye Beck
Figure 2 Temperature Function
Figure 3 Burlington Industries, Stack Sampling Train
Figure 4 Functional Carrier Emission Profile
Figure 5 Air Quality Stack Sampling Train
Figure 6 Curve fit adjusted to test data
Figure 7 Curve fit extended to 1.5 hr/boil
Figure 8 Curve fit extended to 5 minute boil
Figure 9 Percent Biphenyl Loss vs. Boil Time

List of Tables

Table 1 Normal Dye Beck Cycle
Table 2 Test Data
Table 3 Properties of Biphenyl
Table 4 Comparative Emission Losses of Carrier Bases

Introduction

This report discusses the results of source testing conducted on a 20-foot atmospheric dye beck by personnel of Burlington Industries, Bi-Chem Division and personnel of the Air Quality Section of the North Carolina Department of Natural Resources and Community Development. The testing was conducted as a segment of an overall study to determine emissions into the atmosphere in an area surrounding the Mallinckrodt Chemical Plant and Burlington Industries, Wake Finishing Plant. The intent of the study was to determine an emission profile and rate of emissions from a representative dye beck, and by modeling extend the results as an emission factor to other dye becks using different carriers. This study concerned itself with the emission of the organic carrier used in the dyeing of polyester fabric, specifically biphenyl.

Description of Process

The dyeing of polyester fabric with disperse dyes in atmospheric pressure units at room temperature is a very slow if not an impossible process. To overcome this problem and make commercial dyeing both feasible and economical, a system of organic carrier dyeing is used. The process involves the exhaustion of an insoluble disperse dye in water solution on to polyester fabric under the action of a dyeing assistant termed a carrier.

In this case, an aromatic hydrocarbon, biphenyl, is emmulsified and added to the dye bath when the system is at approximately 160° F. The bath is then brought to a boil and the fabric is worked in the liquor until the dye has been exhausted to the required depth of color or shade.

The beck during the dye cycle is closed but not sealed. The beck is maintained at 212° F and the vapor space is kept at a slight vacumn by an exhaust fan which removes the evolved steam.

The venting of the vessel results in a process of steam distillation of the carrier which is present in the bath. The emissions is an aerosol and was sampled in accordance with modified EPA method five techniques.

The beck (figure 1) is approximately twenty feet long and nine feet wide. The liquor volume is approximately 6400 gallons. The fabric weight is 3600 lb/cycle and the biphenyl charge is at 3.40 gram/liter or 170 lb per beck cycle. The beck is loaded with fabric and raised to a boil and maintained for 1.5 to 2.0 hours. The beck is then cooled and the dye shade is matched. The bath may then be dropped or re-run as required to adjust depth of dyeing. A normal temperature profile is provided in figure 2.

Sampling Methods

Stack sampling was conducted by Burlington Industries, Bi-Chem Division using an impinger train followed by a critical

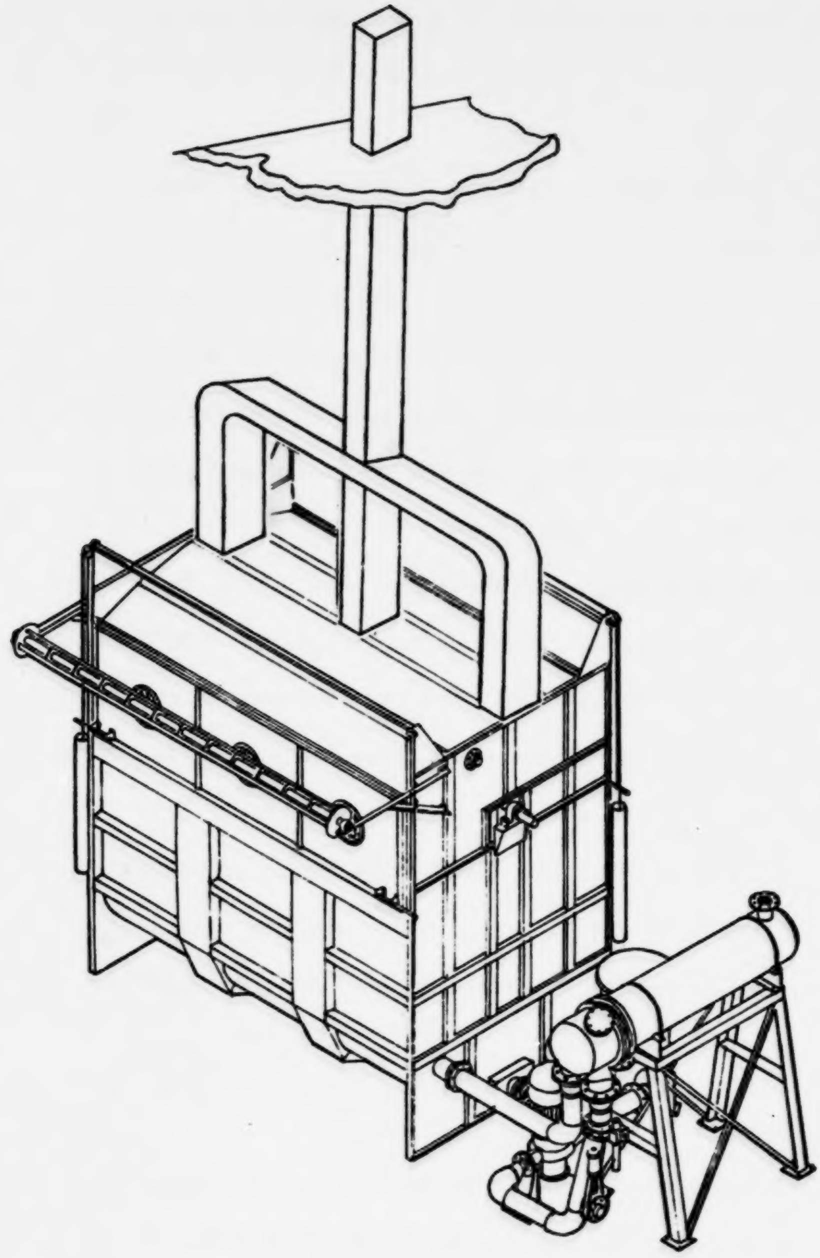

FIGURE 1 ATMOSPHERIC DYE BECK

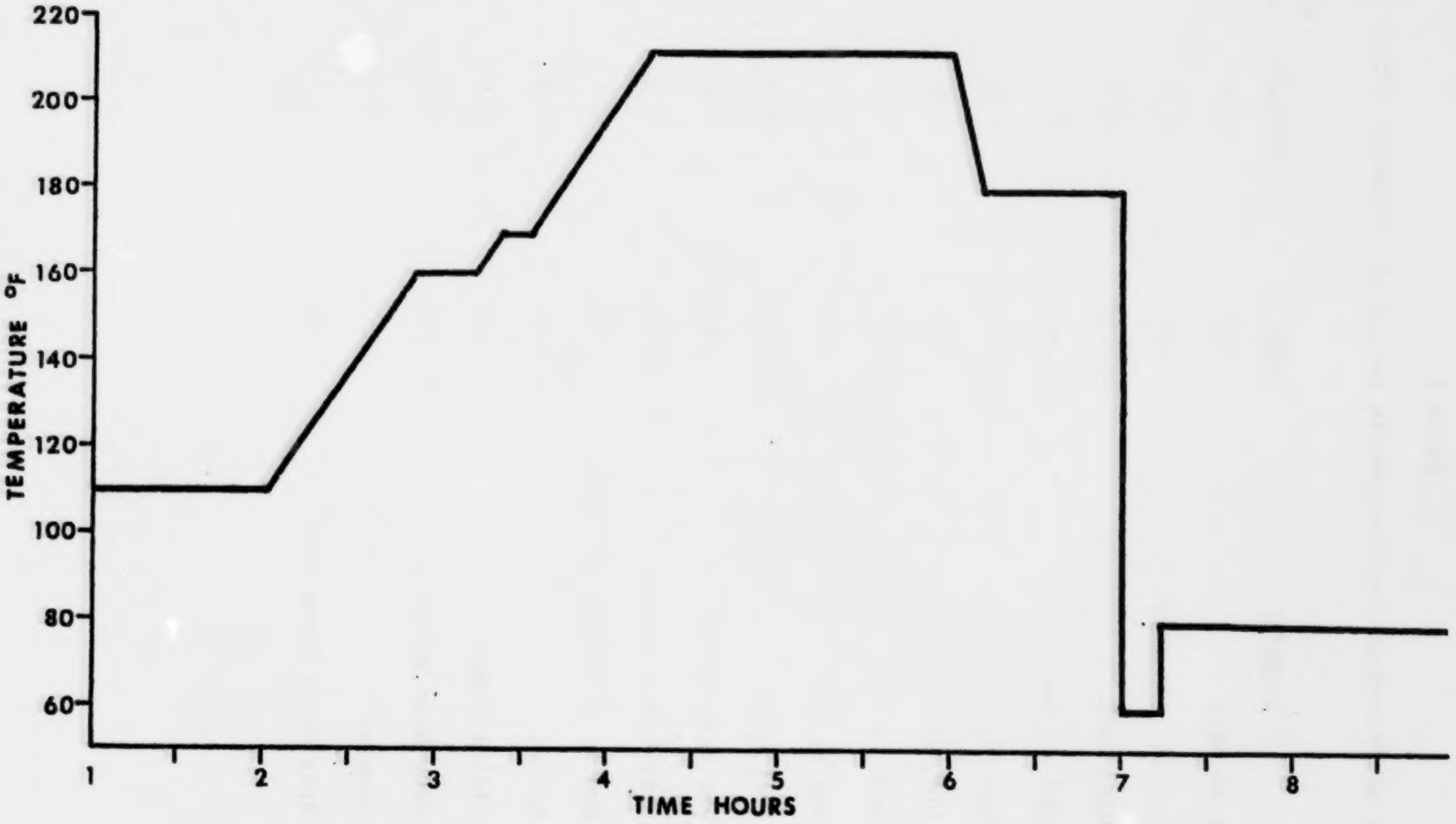

Figure 2 Temperature Profile of a Normal Dyeing Cycle

Table 1

Typical Procedure for Atmospheric Dyeing of Polyester Fabric

	Element	Temp-°F	Time-hr.	Accumulated Time
1)	Load Beck	110	0.8	0.8
2)	Dye in, add salt	110	1.2	2.0
3)	Heat Beck	110-160	0.9	2.9
4)	Add Carrier	160	0.3	3.2
5)	Heat Beck	160-170	0.2	3.4
6)	Add aux. Bath	170	0.2	3.6
7)	Heat to boil	170-212	0.9	4.5
8)	Run at Boil	212	1.5	6.0
9)	Cool Beck	212-180	0.2	6.2
10)	Run Beck (Work)	180	0.8	7.0
11)	Refill Beck Reheat	60-80	0.2	7.2
12)	Run at 80 w/take off Bath	80	0.4	7.6
13)	Unload	80	0.7	8.3
14)	Riding Time	80	0.6	8.9
15)	Drug Room Delays	110	0.1	9.0
16)	Tangles	212	0.1	9.2
17)	Wrap Reels Clean Misc.	60	0.4	9.5
			9.5	

orifice on July 31, 1974. The sampling train is presented in figure 3. The testing was conducted in two runs at different sampling rates. The first at 0.91 liter/minute, the other at 1.92 liter/minute, based on the total stack flow, however, it appears that neither of these rates were isokinetic but the 1.92 liter/minute rate is approximately correct.

Extractions taken from cloth samples after dyeing on previous samples were used as verification of the emission rate. A mass balance was conducted based on fabric carrier retention and the carrier remaining in the bath.

Stack sampling was conducted on two occasions by the stack test team of the Air Quality Section. The first test was to determine the relative rates of emission over the dye cycle as a function of time. Carbon packed tubes were inserted into the stack and a 200 mililiter volume was taken using a Bendix hand sampler. The samples were taken for 6 minutes, at 10 minute intervals over the entire portion of the dye cycle. These tubes were extracted with carbon disulfide and analysis was conducted by gas chromatograph. The samples were not isokinetic, but because of the aerosol nature of the emissions, they were considered proportional. The condensed biphenyl aerosol was assumed to have a very narrow particle distribution and because of the submicron nature could be treated as a gas. This data was used to determine the peak emission period during the dye cycle. The relative

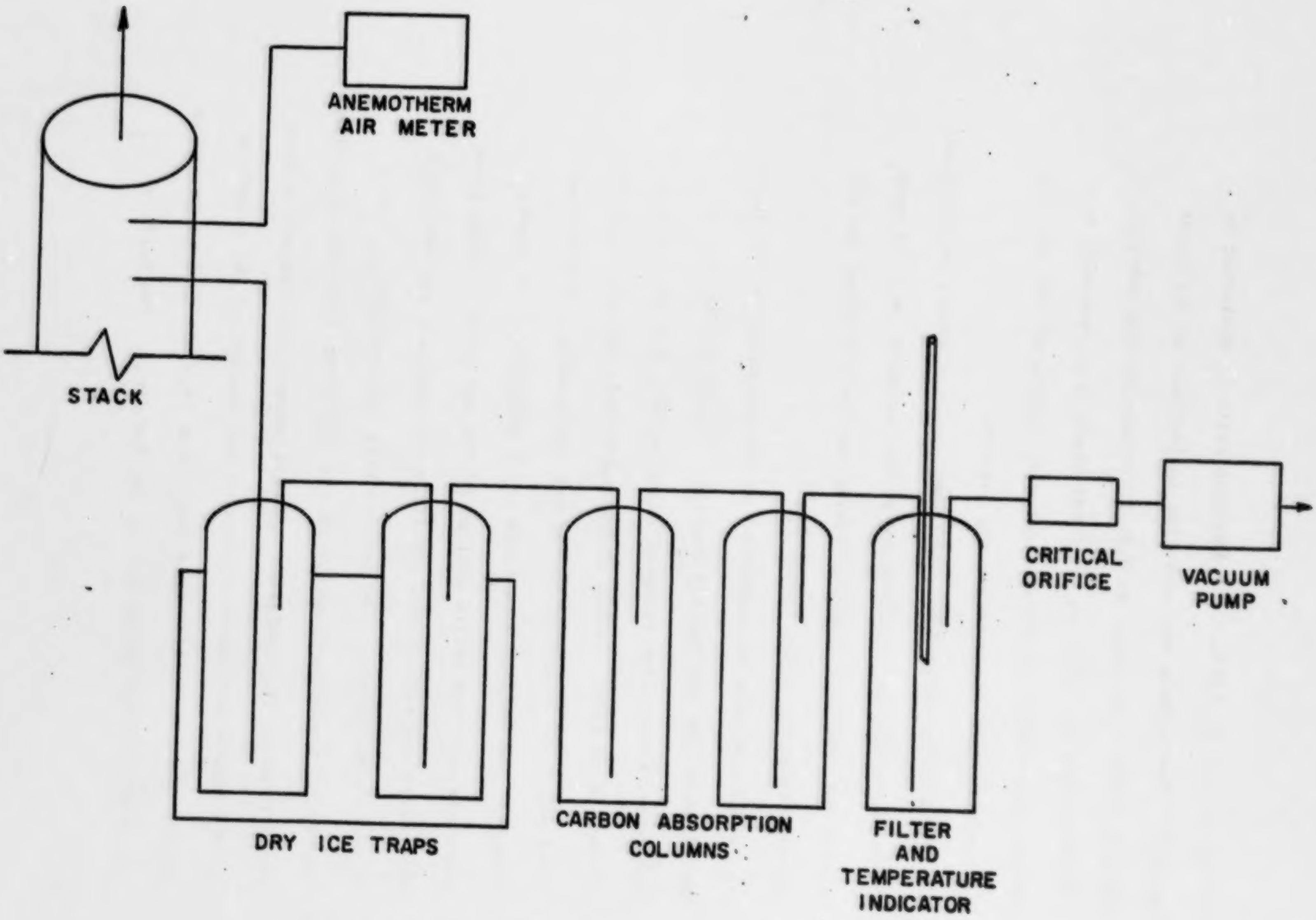
ANEMOTHERM AIR METER
STACK
DRY ICE TRAPS
CARBON ABSORPTION COLUMNS
FILTER AND TEMPERATURE INDICATOR
CRITICAL ORIFICE
VACUUM PUMP

FIGURE 3 BURLINGTON INDUSTRIES SAMPLING TRAIN

concentration of the samples is presented in figure 4.

The stack test team conducted an isokinetic sample for a period of 4 hours on the beck using EPA method 5 techniques. The train consisted of nine (9) glass impingers immersed in a salt-water/ice bath. The ninth impinger contained silica-gel. The biphenyl collected was removed from the impingers by carbon disulfide and an analysis conducted by gas chromatograph. The system was maintained at isokinetic conditions by measuring the wet bulb-dry bulb temperatures at each point and adjustment made for percent moisture continuously during the sample period. The train used is shown in figure 5.

Discussion and Results

Large rates of emission of organic carrier was suspected as a contributor in vegetative damage in the area surrounding Mallinckrodt Chemical and Burlington Industries in North Wake County. In that a good emission factor was not available and no data was available giving the influence of dye cycle variables on emission rates, a joint study was performed by Burlington Industries, Bi-Chem Division and the N. C. Department of Natural Resources and Community Development, Air Quality Section.

An overall program was established to determine the variables which influence the emission rate and the mechanism by which the organic was released. Initial data was obtained by Burlington Industries by solvent extraction of the polyester fabric and

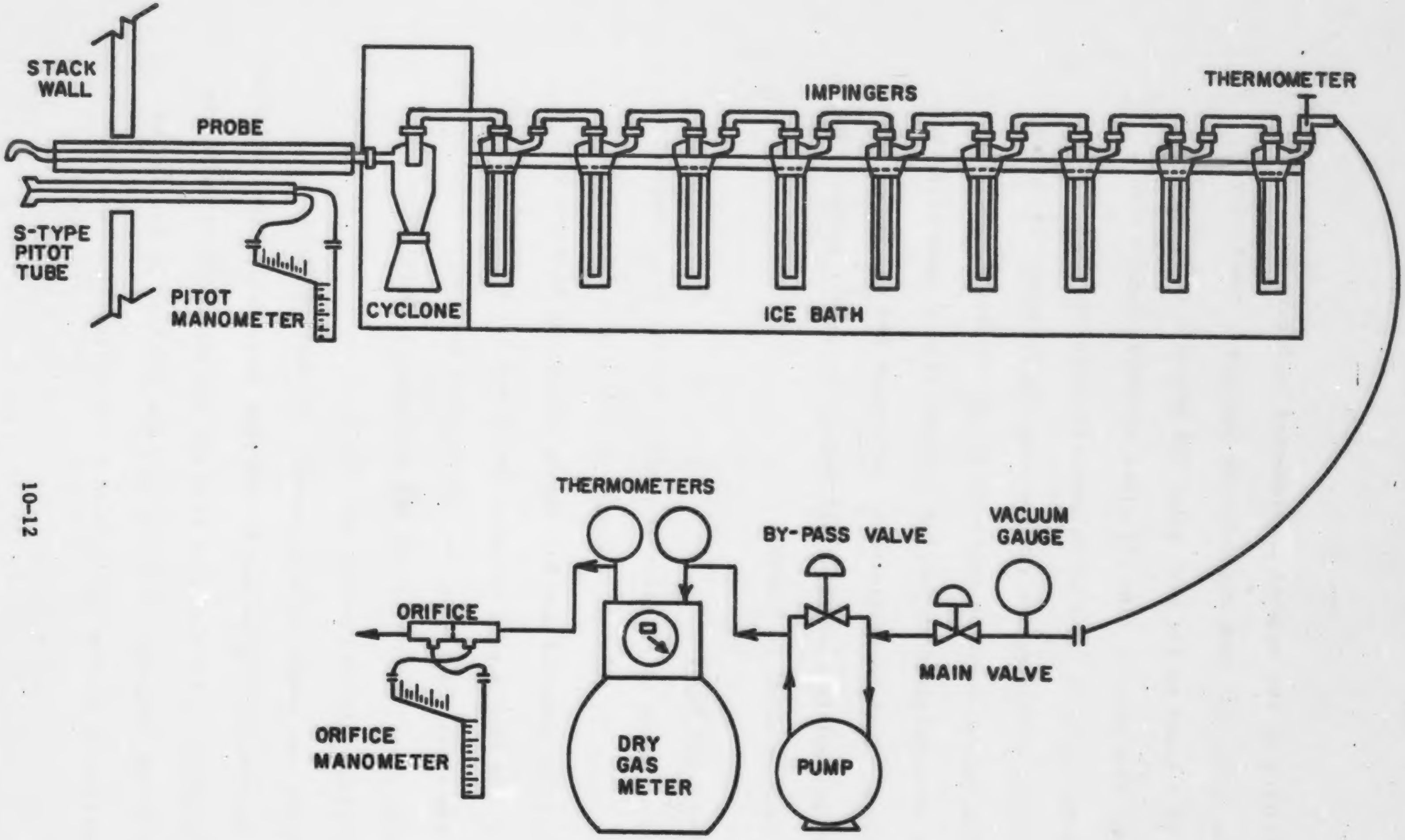
STACK WALL
PROBE
S-TYPE PITOT TUBE
PITOT MANOMETER
CYCLONE
IMPINGERS
ICE BATH
THERMOMETER
THERMOMETERS
BY-PASS VALVE
VACUUM GAUGE
ORIFICE
MAIN VALVE
ORIFICE MANOMETER
DRY GAS METER
PUMP

FIGURE 5 AIR QUALITY SAMPLING TRAIN

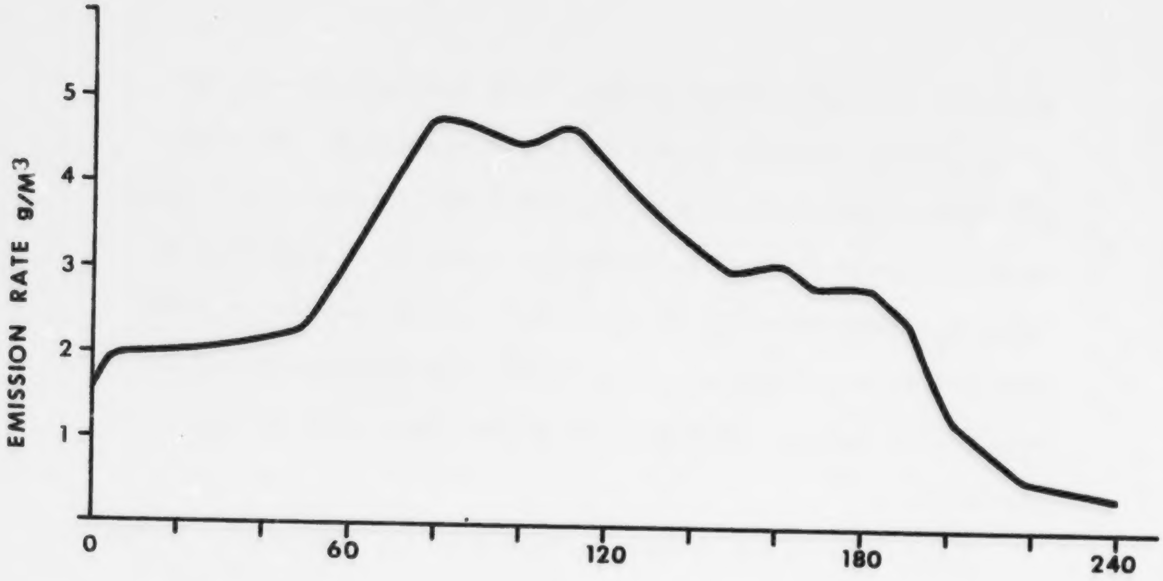

Figure 4 Emissions rate of Biphenyl as of function of time.

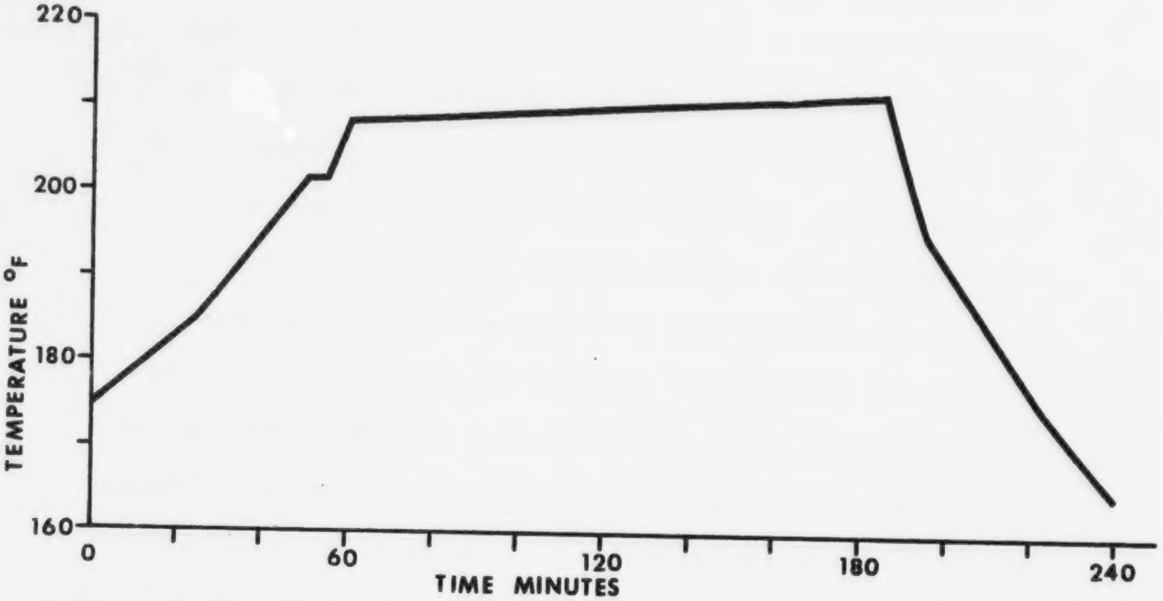

Figure 4A Temperature of dye beck during emission test represented in figure 4.

waste dye bath water after dyeing. This mass balance revealed a significant emission of carrier to the atmosphere. This data was characteristic of a dye cycle with a boil period of 1.5 hours with the normal pre-boil and post-boil sequence as indicated in Table 1. Observation of the beck cycle and the exhaust revealed that the major portion of the emissions were released during the boil period and the other portions of the cycle were of less significance.

The nature of the carrier is such that the atmospheric losses were caused by steam distallation of the biphenyl and exhaustion of the aerosol from the beck with the steam. Burlington performed a number of tests to confirm the losses indicated by the mass balance. The tests were conducted at various sampling rates and the data was inconclusive in determining the true emission rate. One test however, was sufficiently isokinetic to be acceptable. This test indicated an emission rate of 40% of the charge rate. This was in agreement with a 43% loss given by mass balance.

The Air Quality Staff conducted two types of tests on the beck to determine the emission rate as a function of time and the integrated total emission during the cycle. The emission function was determined by the collection of biphenyl on activated carbon at regular intervals during the dye cycle. The carbon was analyzed on a gas chromatograph and the relative emission rate plotted as a function of time. The samples were taken in such a manner as to give a relative emission concentration which was adjusted by a constant value based on an isokinetic source test of the beck at identical conditions. The profile generated by use of the carbon tubes was integrated and the relative values of each sample adjusted to allow for efficiency of collection and desorption. The profile of the emissions is shown in figure 4. The results of the source test indicated a 58% loss for a two hour boil cycle.

The emission rate function was used to generate total emission data at other boil periods. The conditions are shown in figures 6, 7 and 8. The abort condition was considered the minimum emission rate when the beck was not able to reach a boil because of mechanical failure and cooled at the specified rate. The results of the analysis and the test data is presented as function of boil time in figure 9.

The corresponding concentration of biphenyl in the beck waste water is presented in figure 9A. It may be seen that the concentration of biphenyl approaches zero at a two hour boil period. The emission rate to the atmosphere will decrease as the boil is continued in that there is less available carrier in the bath. Continued boiling will not reduce the absorbed biphenyl in the fabric as it acts as a plasticizer in polyester. The absorbed biphenyl may be removed by solvent extraction or sublimation in a tenter frame or dryer.

Extractions were made on dyed polyester cloth before and after

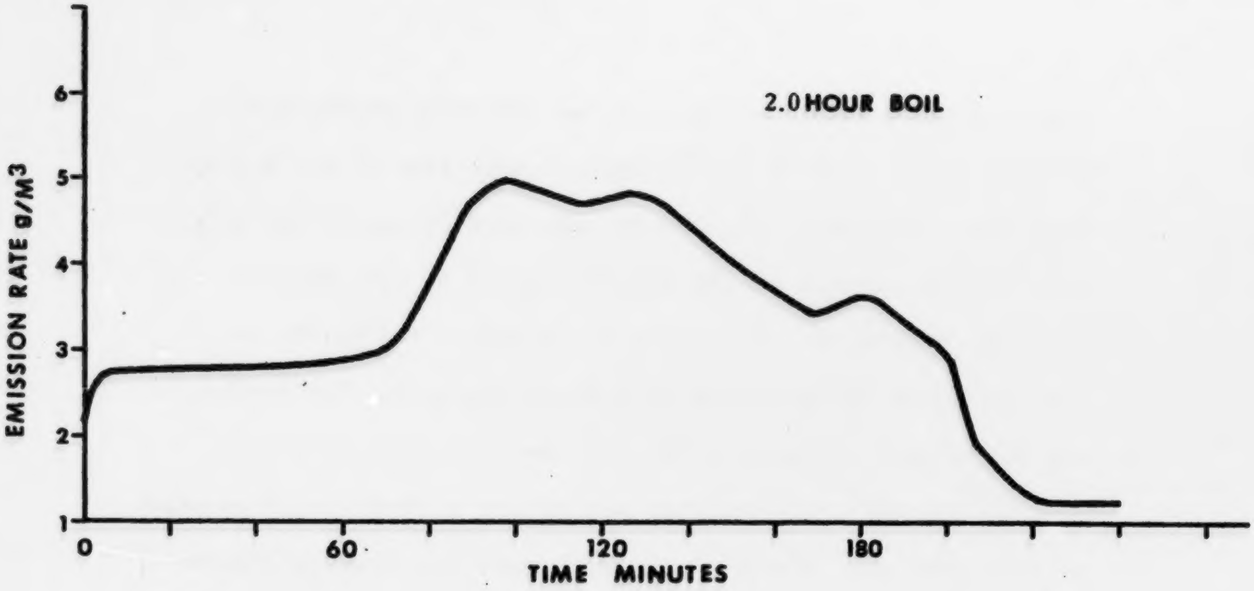

Figure 6 Emission rate of Biphenyl as a function of time adjusted for collection efficiency and desorption efficiency.

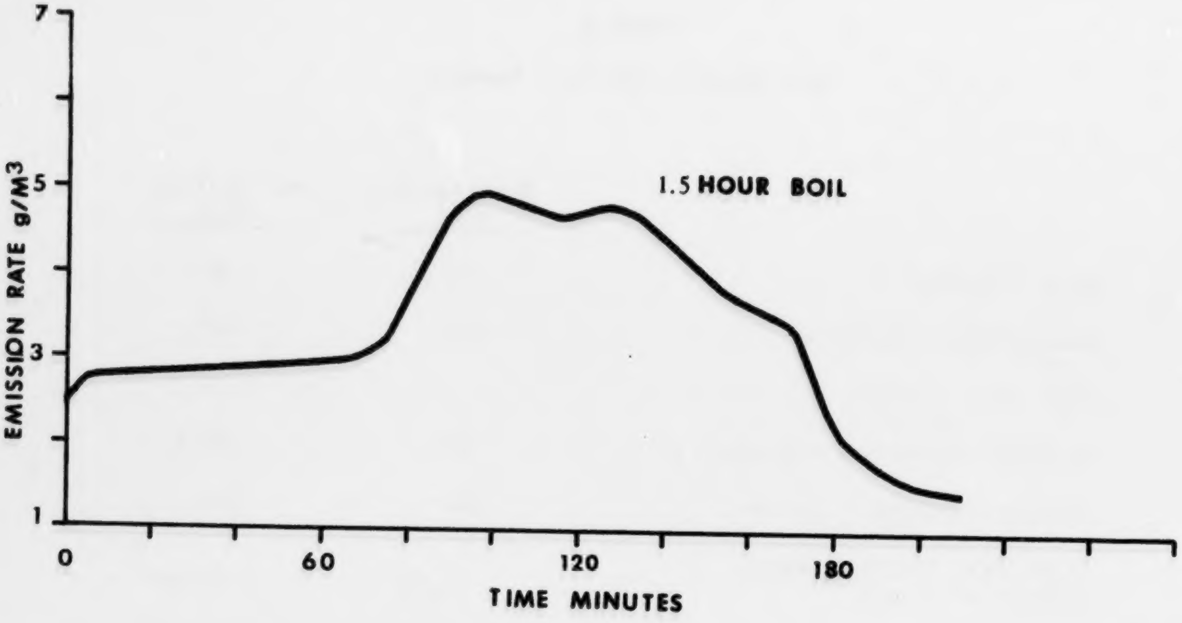

Figure 7 Emission rate of biphenyl as a function of time at one and one half hour boil period.

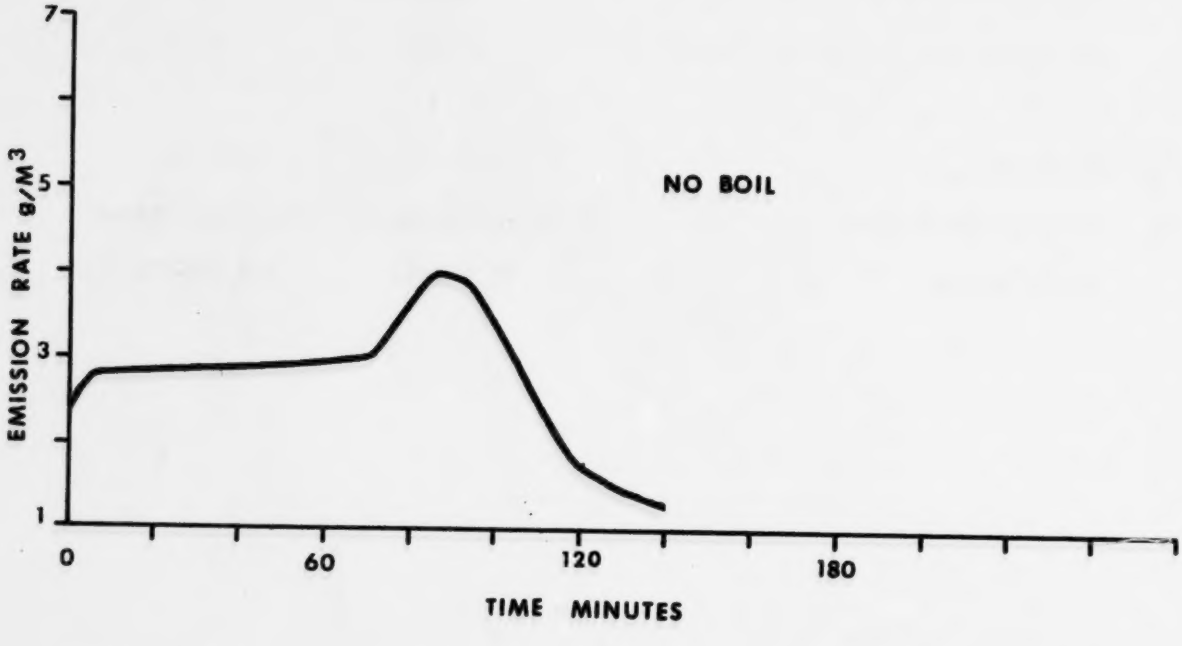

Figure 8 Emission rate of biphenyl as a function of time at no boil period.

Table 2

Mass Balance and Test Results

	Burlington Test	Air Quality Test
Beck - Number	12	10
Sample Time - minutes	180	240
Boil Time - hours	1.5	2
Biphenyl Emissions - pounds	66.3	99.6
Biphenyl Charged - pounds	170	170
Stack Test Emission Rate, Percent of Charge	39.0%	58.6%
Mass Balance Loss, Percent of Charge	42.0%	57.0%
Absorbed by Cloth, Percent of Charge	43.0%	43.0%
Biphenyl Present in Bath at Exhaustion, Percent of Charge	15.0%	0%
Emission Rate lb/100 lb. Cloth	1.84	2.77
Cloth Weight	3600 lb.	3600 lb.
Cloth Construction	Polyester/Rayon	Polyester/Rayon
Cloth Weight	90 lb/cYd	101 lb/cYd

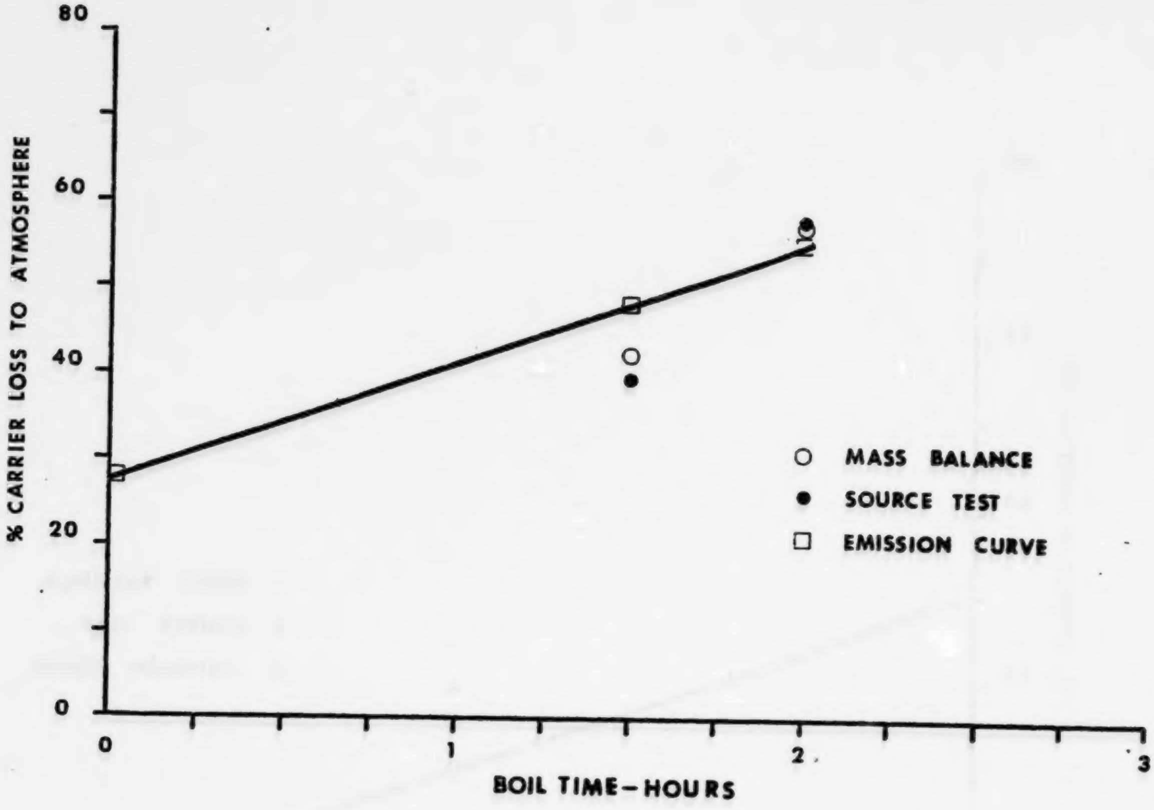

Figure 9 Biphenyl emissions as a function of boil time.

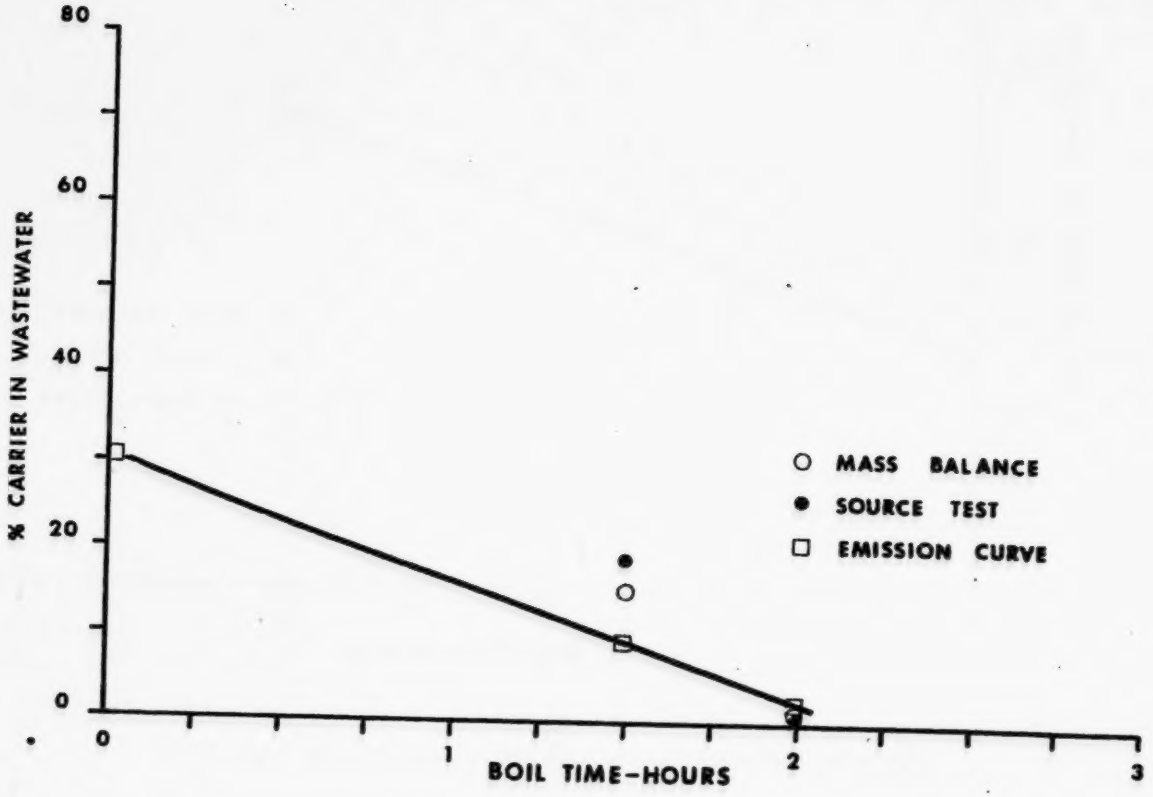

Figure 9A Biphenyl in dye bath water as a function of boil time.

drying in a loop dryer. A mass balance indicated that approximately 60% of biphenyl abosrbed by the cloth during dyeing is evolved. Stack test conducted on the frame exhaust indicated that a 95% of the biphenyl was destroyed in the tenter frame firing system. Further study is needed to derermine the variables influencing the emission rate.

This data may be extended to other carrier systems by correspondence of vapor pressure, heat of vaporization and solubility. Table 4 indicates the comparative loss factors for other carrier systems operated under similar conditions. The analysis assumes the loss factor of 50% for biphenyl at the dyeing conditions.

Conclusions

It is concluded that a significant emission of hydrocarbon carrier is emitted from atmospheric dyeing of polyester fabric. The major variable affecting total emissions is length of boil during the dye cycle. The emission rate is 1.84 lb/100 lb cloth at 1.5 hr boil and 2.77 lb/100 lb cloth at 2.0 hr boil. The close agreement between the mass balance and stack test results indicates that a modified EPA method five is an acceptable method for testing these sources.

Table 3

Properties of Biphenyl

Molecular Weight	154.20
Flash Point	235°F. Closed cup
Explosive Limits	Lower 0.6% at 232°F. Upper 5.8% at 311°F.
Solubility	Near Insoluble in Water (7.7 mg/l at 25° C) Slightly Soluble in Ethonol Soluble in Hydrocarbons
Melting Point	70.5° C.
Boiling Point	256.1° C.
Vapor Pressure	mm Hg 0.001 0.005 0.008 0.010 .050 °C 6.2 20.4 25 27.0 43.5
Odor Threshold	0.06 to 0.29 mg/m^3
At 25° C and 760 mmHg	Saturated air 66 mg/m^3 1 ppm = 0.0063 mg/l 1 mg/l = 158 ppm

Table 4

Comparative Emission Losses of Common Carrier Bases During Atmospheric Dyeing*

Carrier Base	Boiling Point °C	Emission From Dye-Bath Percent of Charge
Biphenyl	255	50
Methyl Cresotinate	---	81
Methyl Biphenyl	263	47
Methyl Napthalene	243	70
Diphenyl Oxide	258	33
Dibenzal Ether	295	12
Methyl Benzoate	199	100
Trichlorobenzene	213	100

*Burlington Industries, Bi-Chem Division

CONDENSED DISCUSSION

Question: Could you elaborate on the variations in emissions rates that you mentioned?

Hawks: Because of the variables involved in the dying operation there are different fabric constructions and different procedures for dying. These vary from company to company and beck to beck in each operation. Where this particular operation occurred the conditions were such that 30,000 gallons of water were present in the becks and 3600 lbs. of cloth were present and that the charge rate was 4.72 lbs. per 100 lbs. of cloth. Different companies use different charge rates. For this reason the emission factor stated would only be good for the particular conditions for which the beck was being operated. So in general, if one needs to know the emission rate, instead of running a stack test, the mass balance seems to be very accurate. It is also noted that when one company was aksed the emissions from these operations they indicated 2,000 lbs per year.

Hawks: (con't) They operate 38 becks varying from 2 feet in length to 20 feet in length. When we did out stack tests and computed our emissions for a year, we found 1.5 million lbs. emitted. So, there is quite a spread on what is thought to be emitted from these and what are actually emitted.

Air Quality and Energy Conservation Benefits From Using Emulsions to Replace Asphalt Cutbacks in Certain Paving Operations

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November 1977

TABLE OF CONTENTS

Page

Executive Summary ii

I. Purpose of Study 1

II. Asphalt Paving-General 1

III. Previous Efforts to Encourage Emulsified Asphalt Use 4

IV. Air Quality Considerations 6

V. Energy Conservation Considerations 9

VI. Eight-State Survey of Paving Practices and Economic Considerations 10

VII. Summary and Conclusions 11

References 14

Executive Summary

This paper examines the air quality and energy conservation aspects of asphalt paving practices using liquefied asphalt. There are two basic types of liquefied asphalt: (1) asphalts liquefied with petroleum distillates such as kerosene or heavy naphtha, called cutback asphalts, and (2) asphalts liquefied using water and an emulsifying agent, called emulsified asphalts. One type of emulsified asphalt (cationic) is "cured" through an electrochemical process. All other types of liquefied asphalt are "cured" through the evaporation of the liquefying constituent. Cutbacks emit reactive hydrocarbons during the curing process; emulsions emit almost no air pollutants.

In 1975 cutbacks accounted for 2.3% of estimated national hydrocarbon emissions. In some states the cutbacks accounted for more than 15% of the state's estimated total hydrocarbon emissions. Some states, e.g., Wisconsin, Indiana, Illinois, Ohio, Pennsylvania, Virginia, and West Virginia, have significant air stagnation problems and require regulatory control of hydrocarbon emissions to attain and maintain oxidant air quality standards. These states also have had significant hydrocarbon emissions attributable to paving with cutbacks. Since asphalt paving operations occur predominantly during warm-weather months, when formation of

oxidants from photochemical synthesis of hydrocarbon emissions is most prevalent, the decreased use of cutback asphalt could provide major assistance in oxidant attainment and maintenance strategies.

It is estimated that in 1975 more than 10 million barrels of petroleum distillates were used nationally to liquefy asphalt for paving purposes. These distillates represent fuels which were evaporated to the atmosphere or were retained in the pavement. The total energy associated with laying one gallon of cutback asphalt as pavement is about 50,200 Btu, while the total energy associated with a gallon of emulsified asphalt is about 2,830 Btu. For these reasons, the use of emulsified asphalt as a replacement for asphalt cutback has energy benefits.

Some paving operators claim three instances when emulsions cannot be substituted for cutbacks: (1) when long-life stockpiles are required, (2) for some emulsions when ambient temperatures fall below about 50°F, and (3) possibly when used as a penetrating prime coat. Others claim that these are not deterrents and that they have had success in using emulsions to replace cutbacks in all applications.

The price difference between the two types of liquefied asphalt was found to be not significant at this time.

Air Quality and Energy Conservation Benefits From Using Emulsions to Replace Asphalt Cutbacks in Certain Paving Operations

I. Purpose of Study

The purpose of this paper is to examine potential reductions in hydrocarbon emissions which may be achieved through substituting one kind of liquefied asphalt for another in certain paving operations. The paper reviews (1) the differences in asphalts liquefied with petroleum distillates (cutback asphalts), and (2) asphalts liquefied using water and an emulsifying agent (emulsified asphalts). Amounts of reactive hydrocarbons emitted when using cutback asphalts are discussed, as well as the substitutability of emulsified asphalts in place of cutback asphalts. Energy conservation considerations are presented, and the results of an eight-state telephone survey of highway paving practices are summarized.

II. Asphalt Paving - General

Asphalt is a by-product of petroleum distillation (natural or manmade) which man has put to use in many different ways. In ancient times he used it in its natural form to caulk boats and ships, as mortar in masonry construction, and as a cement for mending stone tools. Now we use it for roofing, weatherproofing, floor tile, insulating materials, molded electrical equipment, papers, shingles, coatings, and many other applications. One of its better known uses is for pavements. Because of its durability and weather resistant qualities we use it in many different paving applications. These pavement uses can range from a thin layer sprayed on a dirt road to keep down dust, to a heavy duty pavement of thick layers of asphalt mixed with aggregate (crushed rock, gravel, slag or sand) placed on a well prepared base and designed to carry heavy traffic. In between these two extremes, asphalt pavement may be of a wide variety of thicknesses and strengths, depending on the traffic it will have to carry.[1]

Asphalt surfaces and pavements are composed of compacted aggregate and asphalt. Aggregate materials are produced from rock quarries as manufactured stone or obtained from natural gravel or soil deposits. Metal ore refining processes produce artificial aggregates as a byproduct. The aggregate performs three functions. It transmits the load from the surface to the base course, takes the abrasive wear of traffic, and provides a nonskid surface. The asphalt binder holds the aggregate together, preventing displacement and loss of aggregate, and provides a waterproof cover for the base. Asphalts take the form of asphalt cement (the residue of the distillation of crude oils), and liquefied asphalts. Liquefied asphalts are: (1) asphalt cutbacks (asphalt cement thinned, or "cut back" with volatile petroleum distillates such as naphtha, kerosene etc.), and (2) asphalt emulsions (nonflammable liquid, produced by combining asphalt and water with an emulsifying agent such as soap). Asphalt cement, which is semi-solid, must be heated to convert it to a useable liquid. Asphalt cutbacks and asphalt emulsions are produced in a wide variety of types and grades related to intended use, curing time and structural design requirements.

Emulsified asphalts are used widely in the construction and maintenance of pavements ranging from high-traffic-volume highways and airports to low-volume rural roads and city streets. Although emulsions have been available since 1903 and used extensively since the 1930s, recent energy and environmental problems have focused attention on increased use of these materials. The use of emulsions can reduce energy requirements by reducing or eliminating petroleum distillates that are used in liquefied asphalts and by lowering heating requirements, especially in heating aggregates to dry them. The elimination of petroleum distillates also reduces air pollution by eliminating emissions of hydrocarbons evaporated during the curing process.

Asphalt paving is a seasonal operation, with cold temperatures and rainy weather severely limiting construction and maintenance operations. Winter-time paving is usually limited to emergency repairs, although some states have claimed good results even during periods of low air temperature. Some emulsified asphalts (nonionic and anionic) usually are not used when rain is anticipated or when air temperatures fall below 50°F. With cationic emulsions these deterrents are not critical since "curing" depends on the electrochemical action of the positively charged emulsion bonding with the negatively charged aggregate surface. Generally speaking, emulsified asphalt can substitute for cutbacks in almost any application. Some believe that emulsions are not good for priming purposes, others believe that proper soil preparation is the answer, and still others question the very need for priming. Some states have had no success with long-term stockpiling (more than 3-4 weeks) while others, using heated tanks or using mixes with a relatively small amount of fuel included, have had excellent results in stockpiling for a year or more. The same construction equipment used for cutbacks can be used for emulsions. A moderate amount of training (one or two days) is recommended before first using emulsions. This training is readily available from members of the Asphalt Emulsion Manufacturers Association. Local policies which encourage the use of cutbacks are the only known institutional constraints that inhibit the use of emulsified asphalt.

III. Previous Efforts to Encourage Emulsified Asphalt Use

Some of the organizations concerned with energy problems affecting the supply and use of asphalt road paving materials are: Department of Transportation (DOT), Federal Highway Administration

(FHWA), Federal Energy Administration (FEA), U. S. Department of Agriculture (USDA), Forest Service, Environmental Protection Agency (EPA), Transportation Research Board (TRB), National Asphalt Pavement Association (NAPA), The Asphalt Institute (AI), Asphalt Emulsion Manufacturers Association (AEMA), American Society for Testing and Materials (ASTM), American Road Builders Association (ARBA), American Association of State Highway and Transportation Officials (AASHTO), and state and local highway agencies.

In December 1973 and again in January 1974, FHWA issued notices concerning fuel conservation in federally funded highway construction programs. These notices encouraged state officials to minimize the use of cutback asphalts by substituting emulsions and to reduce mixing temperatures. They also provided guidelines on conserving fuel and presented analyses which demonstrated the large quantity of petroleum distillates which could be saved by substituting emulsified asphalts for cutbacks. FEA and EPA studies resulted in the conclusion that increasing fuel prices had already established a trend of increased use of emulsions. To accelerate this trend, FEA contracted with the National Research Council's Transportation Research Board to produce a synthesis report[2] on the use of asphalt emulsions for pavements. This report was widely publicized by DOT and various trade associations. FEA alone distributed 4,700 copies to city and county engineers in December 1975. In October 1975, EPA informed its regional offices by letter of the advantages of emulsified asphalts over cutbacks and advised the regional offices to encourage the use of emulsions to save energy and reduce emissions of hydrocarbons.

Other agencies and organizations have been at work on the problem. For example, NAPA[3] has published a paper on energy conservation in highway paving, AEMA has been making extensive efforts throughout its membership to encourage the use of asphalt emulsions, and USDA Forest Service has published a report on its experience in using asphalt emulsions, as has the Navajo Area Bureau of Indian Affairs.[4] However, only very recently has there been any indication of a trend toward switching from cutbacks to emulsions.

IV. Air Quality Considerations

The volatiles in cutback asphalts release hydrocarbons into the atmosphere in amounts that vary according to the type of cutback.

Cutback asphalts fall into three broad categories: Slow Cure (SC) (sometimes referred to as Road Oil), Medium Cure (MC) and Rapid Cure (RC). Cutback content averages 35% diluents (hydrocarbons).[3] SCs are a fairly heavy residual oil in the Bunker C range. MCs are diluted with a kerosene-type solvent. RCs are diluted with a heavy naphtha or a gasoline-type solvent. For the purposes of calculating hydrocarbon emissions estimates in this document the average value of 35% hydrocarbons is used to demonstrate order of magnitude.

Table 1 is a summary of estimated hydrocarbon emissions resulting from the use of cutback asphalts for paving purposes.[5] The emission calculations are based on the 35% volatiles contained in the cutbacks and on the following estimated evaporation amounts: SC - 20%-30% evaporated (average: 25%), MC - 60%-80% evaporated (average 70%), and RC - 70%-90% evaporated (average: 80%). Results of evaporation rate testing now being done for EPA by Midwest Research Institute form the basis for these estimated evaporation amounts. Most of the loss is believed to take place early during paving operations. Continuing amounts are lost to the atmosphere as time goes by but at an ever decreasing rate.

Table 1. SUMMARY OF NATIONAL HYDROCARBON EMISSION ESTIMATES FROM THE USE OF CUTBACK ASPHALT PAVING PRODUCTS

	Volatiles, tons/year	HC emissions, tons/year
1971	1,916,857	1,146,915
1972	1,830,724	1,112,932
1973	1,975,451	1,210,233
1974	1,613,454	973,516
1975	1,434,895	886,348

It is important to remember that paving operations are seasonal and that the paving season occurs during the warm weather months when formation of oxidants from photochemical synthesis of hydrocarbon emissions is most prevalent. Attempting to arrive at specific answers to questions about photochemical reactivity of the hydrocarbons emitted by cutbacks is complicated by the fact that there are so many cutbacks of varying chemical compositions. The situation is further complicated by the variables of solar radiation, cloud cover, air mass stagnation, hydrocarbon concentrations, and oxidant formation. However, cutbacks can be classified as moderately to highly reactive as far as oxidant formation is concerned.

Emulsified asphalts, on the other hand, consist of asphalt liquefied with water containing an emulsifier. Emulsions are relatively pollution-free with few volatiles to evaporate into the atmosphere.[6] FHWA has pointed out that there may be some distillates in some formulations of emulsified asphalt.

Table 2 indicates the relationship of hydrocarbon emissions from cutback asphalts used in paving, to national hydrocarbon emissions. (Asphalt paving operations are not now included as a source of HC emissions in the national summary).

Table 2. HYDROCARBON EMISSIONS FROM CUTBACK ASPHALT AS A PERCENTAGE OF NATIONAL HC EMISSIONS

	Summary of national HC emissions, 10^6 tons/year	Relationship of cutback asphalt HC emissions to national HC emissions %
1971	33.3	3.4
1972	34.1	3.2
1973	34.0	3.5

1974	32.9	2.9
1975	30.9	2.8

Table 3 shows a breakdown of national hydrocarbon emissions for mobile and stationary sources and displays the emissions from cutbacks in context with the two other sources.

Table 3. U.S. HYDROCARBON EMISSIONS BY CATEGORY[7]
(10^6 tons/year)

	Mobile sources	Stationary sources	Cutback sources
1971	13.7	19.6	1.1
1972	14.0	20.1	1.1
1973	13.7	20.3	1.2
1974	12.5	20.4	1.0
1975	11.7	19.2	0.9

It is further noted that some states experience frequent air mass stagnation and have oxidant air quality problems. Some of these states, e.g., Wisconsin, Indiana, Illinois, Ohio, Pennsylvania, Virginia and West Virginia, require regulatory control of HC emissions for attainment and maintenance of oxidant ambient air quality standards. Most of these states also have significant quantities of hydrocarbon emissions attributable to paving with cutback asphalts.

V. Energy Conservation Considerations

In 1975, 10,249,250 barrels of petroleum diluents were used to liquefy asphalt for road paving operations. This amount of cutback is equivalent to 464,906,000 gallons of gasoline, enough to fuel almost 558,000 automobiles for a single year in the United States. Rather than powering automobiles, airplanes, or industry, however, energy in the form of diluents was poured onto road surfaces, where some evaporated and some remains. The energy impact of using cutback asphalts is just as striking when viewed in terms of the energy expended per gallon of paving material. The total energy associated with manufacturing, processing, and laying one gallon of cutback asphalt is about 50,200 Btu. On the other hand, analysis of emulsified asphalts shows that about 98% of the petroleum diluents is replaced with water with the result that only about 2,830 Btu is associated with each gallon of paving material.

VI. Eight-State Survey of Paving Practices and Economic Considerations

State highway maintenance divisions in eight states were contacted for information, opinions, and experiences regarding the use of emulsified asphalt paving materials. The states selected for this survey were the larger users of asphalt. Since each state is responsible for some fraction (which may differ for each state) of the roads within its boundaries, this survey addresses only those asphalt paving operations for which the state is directly responsible.

In general, the survey showed that there has been an increased use of emulsified asphalts. This increased use, which varies with each state contacted, has been brought about primarily through fuel conservation measures and economic considerations. Relatively little consideration is given to HC emission from paving operations. For example, in Allegheny County, Pa., the Pennsylvania DOT uses emulsified asphalts almost exclusively for county road paving operations because of conservation and economics. In areas where such considerations do not exist, the choice of emulsified asphalt or cutback asphalt depends largely upon user preference as well as experience in specific materials and suppliers.

Individual responses ranged from general acceptance of emulsified asphalts for paving to indifference and skepticism about emulsions. Pennsylvania has changed from 30% emulsions/70% cutbacks in 1973 to 70% emulsions/30% cutbacks today. New York State uses 97% emulsions/ 3% cutbacks.

New York and Pennsylvania have initiated training programs to instruct their personnel and contractor personnel in the correct use of emulsions.

VII. Summary and Conclusions

The air quality and energy conservation aspects of the use of liquefied asphalt for paving operations have been analyzed to determine the potentials for energy savings and reduced emissions. Cutback asphalts are liquefied with hydrocarbon distillates such as kerosene or naphtha; these reactive hydrocarbons are emitted during the curing process. Emulsified asphalts use water and an emulsifying agent for liquefaction; virtually no pollutants are emitted during the curing of emulsions. Some suppliers of emulsified asphalt include small amounts of distillates in their emulsions. In such cases the amount of hydrocarbons emitted would be a function of the amount of distillates used.

Overall, more than 10,000,000 barrels of distillates are used annually for paving purposes. Most of this is evaporated into the atmosphere; the remainder is retained in the pavement. Use of emulsions would save much of those 10,000,000 barrels of distillates for use as or conversion to fuels.

In some states the curing of cutback asphalts accounted for a significant amount of the state's total annual hydrocarbon emissions. This problem is made more serious by the fact that asphalt paving operations take place primarily during warm weather when oxidant formation from the photochemical synthesis of hydrocarbon emissions is most likely. Reduced use of cutback asphalts could decrease materially the oxidant problem in these states.

It is anticipated that a minimal amount of cutback asphalt will continue to be used at air temperatures lower than 50°F and for dusty surfaces. Also, some cutbacks will be used where portable plants are not available, because the stockpile life of emulsions is a problem for some operators. Other concerns can usually be met through good management.

Significant energy savings and air quality improvements can be realized from the increased use of emulsified asphalts.

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CONDENSED DISCUSSION

Question: Comparing the asphalt cement to emulsions, nothing was said about the quality of the surface. What's the binding action of emulsions as compared to hot mix?

Kirwan: My remarks were addressed solely to the liquid asphalts or cutbacks. There is a great deal of controversy about the relative structural efficiencies of these asphalt mixes and the basic paving material concerned. And a very strong school of thought in the asphalt industry says that you need a ratio of about 1.4 to 1. In other words that you need almost 1½ times as much emulsified asphalt for these basic pavement mixes. One school of thought says that this is not true; that you can use these mixes equally and they hold up perfectly well. Our opinion is that it is largely dependent upon the experience of the people that are using the materials. As far as the liquified asphalt is concerned, we have been able to detect no difference as far as the structural efficiency and the wear qualities.

Question: Do you find that there are any hydrocarbon emissions after the asphalt is put into place, during the life of it? In other words, is evaporation of binder why people have to renew their driveways?

Kirwan: Generally speaking, yes. There is also an oxidizing process that goes on and over a period of time asphalt just deteriorates and needs to be replaced or resurfaced. MRI is now testing emissions and weight loss to determine the amount of hydrocarbons emitted and also trying to get a fix on the rate of emissions. Emissions are very rapid at first but it goes on for a fairly long period of time. In the south in particular, I am sure any of us who have traveled in the summer can recollect driving over asphalt roads, particularly out in the country and getting that very strong hydrocarbon odor on a road that has been paved maybe last year or the year before.

Question: Is there any difference in labor cost in putting down the two types of liquidified asphalt?

Kirwan: There is no difference.

Question: Have the petroleum companies been consulted as to how they would reprogram their refineries to using the oils that are now being used as cutback? In other words they may not be up to the grade that would be used for fuel oil and other uses.

Kirwan: No. However, using experts from the Asphalt Institute and asphalt chemists from industry as well as our own in-house people who are refinery experts, we feel confident that the petrochemical industry would readily utilize any of this material that is released.

ENVIRONMENTAL PROTECTION AGENCY

REGION IX

SURVEILLANCE & ANALYSIS DIVISION

Title: Commercial Bakeries as a Major Source of Reactive Volatile Organic Gases

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Summary:

The baking industry appears to represent a major source of photochemically reactive volatile organic gases in the form of ethyl alcohol and other gases. Yeast fermentation of bread baking doughs produces pyruvic acid and acetaldehyde as intermediate products and about equal molar amounts of ethyl alcohol and carbon dioxide gas (CO_2) as final products. Recent source tests performed by an EPA contractor have validated theoretical estimates of the magnitude of the emissions. Emission factors are presented in this paper on a per capita and production rate basis. Large bakeries can emit up to 168 tons/year of ethyl alcohol.

Purpose:

The purpose of this report is to provide information on volatile organic gas emissions from the baking industry in order that emission estimates can be included in emission inventories currently being developed in EPA, Region IX.

Background:

The art of bread baking has changed little in the 2,000 years since the Egyptians discoverd the leavening of bread. The basic ingredients of bread are flour, water, salt, sugar, and yeast. Other ingredients are added to enhance the flavor or texture of the desired product.

The role of the yeast in bread baking is to produce carbon dioxide gas. The evolving CO_2 raises or "leavens" the bread dough to a desired volume. Yeast produces the CO_2 by anaerobically decomposing the sugar in the natural metabolic process known as alcoholic fermentation. Alcoholic fermentation of sugar by yeast produces equal amounts of CO_2 gas and ethyl alcohol, with pyruvic acid and acetaldehyde also produced as intermediaries.

In a commercial bakery, bread dough is allowed to ferment from two to four hours prior to baking at an oven temperature of 450°F. The temperature inside the bread does not exceed 212°F. The ovens used in commercial bread bakeries are predominately fired by natural gas and are direct fired. In direct fired ovens, any vapors driven off the bread and any combustion product gases are removed throught the same exhaust vent. The aroma associated with fresh baked bread, in the locale of a bakery, is actually fermentation of alcohols, aldehydes, and possibly other organics being emitted to the atmosphere.

It is believed that alcohol is produced as a liquid within the bread dough during the fermentation period.(1) Part of the alcohol is driven off the bread during oven baking. Since the oven is operating at 450°F, it may be possible that the alcohol is undergoing a chemical reaction, such as dehydrogenation to form aldehydes or esters, before it is exhausted from the oven.

Also since a carboxylic acid (pyruvic) and acetaldehyde are produced as intermediaries, these substances too could be undergoing some type of chemical reaction prior to being exhausted from the oven.

Bakery products can be divided into two groups; products that are yeast leavened, and products which are chemically leavened by baking powder. This review is only concerned with yeast leavened bakery products. Yeast leavened bakery products include most breads, sweet rolls, sweet yeast goods, ordinary crackers, pretzels, and doughnuts excepting cake doughnuts. Chemically leavened bakery products include cakes, cookies, cake doughnuts, and quick breads such as corn bread or baking powder bisquits.(2)

STOICHIOMETRY AND MECHANISM OF ALCOHOLIC FERMENTATION BY YEAST:

The following chemical reactions occur during yeast fermentation of sucrose:

$$\underset{\text{(sucrose)}}{C_{12}H_{12}O_{11} + HOH} \longrightarrow \underset{\text{(fructose)+(glucose)}}{C_6H_{12}O_6 + C_6H_{12}O_6}$$

$$2C_6H_{12}O_6 \xrightarrow{\text{yeast enzymes}} \underset{\text{(pyruvic acid)}}{4CH_3COCOOH}$$

$$4CH_3COCOOH \xrightarrow{\text{yeast enzymes}} \underset{\text{(acetaldehyde)}}{4CH_3CHO} + 4CO_2$$

$$4CH_3CHO \xrightarrow{\substack{\text{yeast}\\ \text{enzymes}}} 4CH_3CH_2OH$$

(ethyl alcohol)

CALCULATION OF ETHYL ALCOHOL PRODUCED PER TON OF SUCROSE CONSUMED:

For each mole of sucrose consumed four moles of ethyl alcohol are produced.

Molecular weight of sucrose =

$$\begin{aligned} C_{12} &= 12 \times 12 = 144 \\ H_{22} &= 22 \times 1 = 22 \\ O_{11} &= 16 \times 11 = \underline{176} \\ & \qquad 342 \text{ lb./lb. mole} \end{aligned}$$

The number of pound moles of sucrose in 1 ton =

$$\frac{\text{lb. moles}}{\text{ton sucrose}} = \frac{2000 \text{ lb.}}{\text{ton}} \; \frac{1 \text{ lb. mole}}{342 \text{ lb.}} = 5.8$$

Since for each mole of sucrose consumed four moles of alcohol are produced, therefore, for each ton of sucrose consumed there are 23.4 lb. moles of alcohol produced.

$$\underline{\text{5.8 lb. moles sucrose}} \quad \underline{\text{4 lb. moles alcohol}} = \frac{\text{23.4 lb. moles alcohol}}{\text{ton sucrose}}$$

Molecular weight of ethyl alcohol =

$$\begin{aligned} C_2 &= 12 \times 2 = 24 \\ H_6 &= 6 \times 1 = 6 \\ O &= 16 \times 1 = \underline{16} \\ & \qquad 46 \text{ lb./lb. mole} \end{aligned}$$

Pounds of ethyl alcohol produced per ton of sucrose consumed is =

$$\frac{\text{lb. ethyl alcohol}}{\text{ton sucrose}} = \frac{\text{23.4 lb. moles alcohol}}{\text{ton sucrose}} \quad \frac{\text{46 lb.}}{\text{lb. mole alcohol}}$$

$$= \frac{\text{1076 lb. ethyl alcohol produced}}{\text{ton sucrose consumed}}$$

$$\text{or,} \quad = \frac{\text{.54 lb. ethyl alcohol produced}}{\text{lb. sucrose consumed}}$$

However, it is not necessary for sucrose or any other sweetener to be added to the bread for alcohol to be evolved. In the absence of a carbohydrate sweetener, the yeast will reduce carbohydrates in the wheat to maltose and ultimately to ethyl alcohol and carbon dioxide. A good example of a bread made without an added sugar is some of the San Francisco sour dough breads.

Therefore, the amount of ethyl alcohol could be greater than the value calculated for each pound of sucrose consumed.

ESTIMATION OF BAKERY EMISSIONS BASED ON BREAD PRODUCTION RATES:

The nation's largest bread baker, Continental ITT(3) and the major manufacturer of commercial baking ovens, Baker-Perkin(5) were contacted to determine if any studies had been conducted or tests performed to establish volatile organic gas emissions from the fermentation process in commercial bakeries. It was learned that there is no reliable information available to estimate emissions from the baking industry. A source test was performed by Baker-Perkin's contractor, Clayton Environmental, during August, 1974, on a direct fired commercial bakery oven. The hydrocarbon emission rate from this test was determined to be 1 lb. HC/1000 lb. bread. However, according to Continental ITT, this test only measured hydrocarbons (i.e. compounds containing only hydrogen and carbon). Ethyl alcohol, acetaldehyde, and pyruvic acid are not strictly hydrocarbons as they contain oxygen in addition to hydrogen and carbon. Also, the test was considered to be unreliable and not reproducible by Continental ITT observers on the scene.

Continental ITT is the largest baker in the country, producing Wonder Bread, Hostess Cupcakes, Hostess Twinkies, and many other name brand baked goods. At the request of the EPA Regional Office, Continental ITT's Research Department developed an estimated emission factor of:

$$\frac{\text{8.0 lb. ethyl alchohol emitted}}{\text{1000 lb. bread baked}}$$

The emission factor estimated by Continental ITT is based on the following assumptions:

(1). 8-10% of bread's dough weight is sugar

(2). 10-15% of sweet rolls' dough weight is sugar

(3). Only 2-3% of the bread or seeet rolls' dough weight is consumed and attributable to alcoholic fermentation

(4). 50% of the dough weight loss is converted to alcohol

(Note - this correlates well with the weight of alcohol produced per pound of sugar consumed, which was calculated as 54% earlier in this report.)

(5). Some of the alcohol remains in the bread

(Note - Continental ITT is estimating that between 25% and 53% of the alcohol produced remains in the bread.)

Based on the information provided by ITT Continental, it was calculated that a large commercial bakery could emit over 100 tons/year of volatile organic gases.

In order to develop an accurate estimate of emissions from this source, EPA contracted with Midwest Research Institute (MRI), Kansas City, Missouri, to perform source tests.(7) The first test was conducted during August, 1977. Two loaves of bread, each weighing approximately 1.6 pounds were baked in the laboratory. A straight dough mix was used with a sugar concentration of 5.3% by dough weight. Plastic tents were constructed over the areas where the bread was mixed, kneaded, and allowed to rise. Sampling probes were placed in the oven during baking.

A gas chromatograph (G.C.) sampling pump continuously withdrew samples for analysis from within the plastic tent. The emission rates of the hydrocarbons were obtained by knowing the flow rate of the G.C. sampling pump and obtaining the concentration on the flow stream from the G.C. An overall emission factor of about .8 lb. ethyl alcohol per pound of bread produced was calculated from this test data. However, this test was not considered valid for the following reasons:

1. The bread mix was straight dough and not a commercial sponge dough process. Home baked breads are normally straight dough mixes while commercial breads are normally sponge dough mixes.
2. The sugar concentration in the straight dough mix was only 5.3%. Sponge dough mixes would contain approximately 10% sugar.
3. The testing was discontinued when the bread was removed from the oven which is at the peak of its ethyl alcohol emissions.
4. The yeast used was not a commercial grade yeast.

A second laboratory test was conducted in November, 1977, by MRI. In this test, a sponge dough mix was used and the yeast was a commercial grade obtained from the local Wonderbread bakery. However, the sweetener concentration in the dough was only 5%.

In this test, the cumulative emission factor for the entire baking process was approximately 3.0 lb. of ethyl alcohol emissions per 1000 pounds of bread produced. Almost the entire amount of this emission is evolved during the baking phase.

Based on these two tests, there appears to be a linear relationship between sweetner concentration and emissions. If this assumption is correct, then ethyl alcohol emissions of approximately 8.0 lb./1000 lb. of bread would be expected from a commercial dough mix with a sweetener concentration of 10%.

During January, 1978, it is expected that M.R.I. will complete a third experiment, using a sweetner concentration of 10%. A final report, including all test data, should be available from M.R.I. after this test is completed.

CALCULATION OF EMISSIONS FOR A LARGE COMMERCIAL BAKERY

Using this emission factor, a calculation was made for a large commercial bakery.

Assuming that a large commercial bakery:

(1) produces 12,000 lb. bread/hr.;
(2) operates 14 hr./day;
(3) operates 250 day/year,

the calculated emissions for this bakery using the Continental ITT emission factor would be:

$$\text{alcohol} = \frac{1\ \text{ton}}{2000\ \text{lb.}}\ \frac{12{,}000\ \text{lb. bread}}{\text{hour}}\ \frac{8.0\ \text{lb. alcohol}}{1000\ \text{lb. bread}}\ \frac{14\ \text{hr.}}{\text{day}}\ \frac{250\ \text{days}}{\text{year}}$$

$$\frac{\text{ethyl alcohol emitted}}{\text{year}} = \frac{168\ \text{tons}}{\text{year}}$$

This estimate represents the worst case situation, as it is an example of a very large commerical bakery. A small commercial bread bakery may produce only 2,000 lb./hr and only operate 8 hours per day.

ESTIMATION OF BAKERY EMISSIONS ON A PER CAPITA BASIS:

The following table lists annual yeast leavened baked goods production, excluding retail single-shop bakeries:

PRODUCTS	THOUSAND POUNDS/YEAR
White bread	8,861,343
White hearth bread	426,998
Whole wheat and other dark wheat breads	643,216
Rye breads	509,545
Raisin and other speciality breads	419,506
Rolls-bread type	2,063,124
Sweet yeast goods	875,053
Crackers	1,369,194
Pretzels	139,380
Total	15,307,359

The source of this information is the U.S. Census Bureau for the year 1966. However, it is reported that these figures have not changed appreciably in recent years.(2) Although single retail bake shops are not included in this listing, they are not considered to be a major factor in the baking industry.

The population of the United States for 1976 was 213.6 million.(6)

$$\frac{\text{lb. yeast leavened bake goods consumed}}{\text{person-year}} =$$

$$\frac{\text{15,307,359,000 lb. bake goods}}{\text{213,600,000 person-year}}$$

$$= 71.7\ \text{lb.}\ \frac{\text{yeast leavened bake goods consumed}}{\text{person-year}}$$

Using the emission factor of 8.0 lb. ethyl alcohol emitted/1000 lb. baked goods, the ethyl alcohol per person per year would be:

$$= \frac{\text{8.0 lb. ethyl alcohol emitted}}{\text{1000 lb. bake goods}} \quad \frac{\text{71.7 lb. bake goods}}{\text{person-year}}$$

$$= \frac{\text{.57 lb. ethyl alcohol emitted}}{\text{person-year}}$$

It should be noted that this estimate includes emissions from cracker and pretzel baking which comprise less than 10% of the total production of yeast leavened bake goods. The emission factor of 8.0 lb. alcohol emitted per 1000 lb. bread baked, estimated by Continental ITT, does not apply to crackers and pretzels, as these products are not manufactured by this company. However, lacking any additional information, the Continental ITT emission factor was also applied to cracker and pretzel baking.

ESTIMATE OF BAKERY EMISSIONS IN THE SOUTH COAST AIR BASIN:

For illustrative purposes, an estimate of bakery emissions for the approximately 11 million people residing in California's South Coast Air Basin (greater metropolitan Los Angeles area) would be:

$$= \frac{.57\text{ lb. alcohol emitted}}{\text{person-year}} \quad 11{,}000{,}000\text{ persons}$$

$$= \frac{6{,}270{,}000\text{ lb. ethyl alcohol emitted}}{\text{year}}$$

$$\text{Or,} \quad = \frac{6{,}270{,}000\text{ lb.}}{\text{year}} \quad \frac{1\text{ ton}}{2{,}000\text{ lb.}}$$

$$= \frac{3{,}135\text{ tons}}{\text{year}} \quad \frac{1\text{ year}}{365\text{ days}}$$

$$= \frac{8.6\text{ tons}}{\text{day}}$$

The total stationary source emissions on non-methane organics in the South Coast Air Basin for 1974 are estimated at 651 ton/day.(7) The percentage of emissions from stationary sources in the South Coast Air Basin due to bakeries is:

$$= \frac{\frac{8.6\text{ ton}}{\text{day}} \quad 100}{\frac{651\text{ ton}}{\text{day}}}$$

$$= 1.3\%$$

The following table compares emissions from commercial bakeries in the South Coast Air Basin to other major source categories; for Non-Methane Hydrocarbons (NMHC) for 1974:(6)

Stationary Source Category	% Total NMHC Emissions
Miscellaneous Organic Solvent Usage	26.8
Surface Coating (Painting, etc.)	25.5
Petroleum Marketing	24.0
Petroleum Refining	7.3
Solvent Degreasing	5.8
Dry Cleaning	4.4
Structural Fires	4.2
Utility Equipment (lawn mowers, etc.)	3.1
Wild Fires	2.3
Pesticides	1.4
Commercial Bakeries	1.3
Power Generating Plants	1.3
Petroleum Refining-Fuel Combustion	.8
Orchard Heaters	.6
Industrial Fuel Combustion	.5
Petroleum Production	.4
Metallurgical Processing	.4

According to this estimate, commercial bakeries would be the 11th largest NMHC emission category, within the South Coast Air Basin, according to this system of classifying sources.

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CONDENSED DISCUSSION

Question: What type was the oven and how did you sample the emissions from it?

Keller: (MRI) Our oven was an electric heating oven. We had three holes in the top of the oven and we had glassware coming out of the holes and hooked into our GC. We had flow rate measured out the top. We thus knew the concentration and the flow rate coming out the top. We also believe because of our realitively high flow rate coming out of the oven, we did not have any organics turning back onto the electric heaters on the bottom of the oven.

Question: How did you measure flow from the first of the operation?

Keller: The GC unit has a sampling rate of 2.8 cubic feet per minute. The holes were stuck into a bag that had an inlet that was just open to clean air so that the GC pulled out 2.8 and supposedly clean air came in at 2.8.

Question: How do you feel about the statistical significance of only using two loaves for developing emissions factor? You only did two loaves - you are going to do two more.

Keller: Yes, 1500 grams.

Question: Why not make 20 or 30 continuously so you identify the different variances?

Henderson: Well we are not baking 20 or 30 because of money constraints. It took six man days to do the analysis and baking of just two loaves of bread. This is quite a lot of money. I believe that the two or four loaves we make will provide fairly representative emission factors. We will be using a process similar to what bakers use and we are making sure our bread and dough is homogenious and that it is representative of the "standard" loaf of bread.

Keller: Again, this was a first look to see how close we came to the theorical values. If we come out the second time and we find we are far off then we may discuss with the project officer to see if we should load up our equipment, contact a baker and go out to get field samples.

Question: What were the other species that you measured besides ethyl alcohol? Was there anything else picked up in the GC?

Keller: We found the ethyl alcohol was 95% of the hydrocarbons coming out. There was no methane. The other 5% of hydrocarbons had a boiling point similar to ethanol. As we pointed out there are a couple other organic species that could be coming out, but we did not sample to see what they were. We also did not sample the water emission rate.

Report No. PD-77-002

REACTIVE ORGANIC GAS EMISSIONS FROM PESTICIDE USE IN CALIFORNIA

Report

By

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(This report has been reviewed by the California Air Resources Board and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the Air Resources Board, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.)

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*Due to travel limitation Mr. Wiens was not able to attend the workshop but his paper is included for informational purposes.

ABSTRACT

This report identifies pesticide use as a major source of reactive organic gas emissions in agricultural areas of California. Inventories using existing assessment methodology show pesticide emissions to be too low to be of significant interest. Although data sufficient to develop a reliable emission assessment were not found, the information found does indicate pesticide emissions nearly ten times larger than found in existing inventories.

The Pesticide Use Report, published by the California Department of Food and Agriculture, includes only 14% of the nonsynthetic organic materials actually applied, and 52% of the synthetic organics. The petroleum products used as or with pesticides are estimated to be 90% volatile instead of 10% as found in existing assessment methodology.

California pesticide use in 1975 resulted in an estimated 339 tons/day of reactive organic gas emissions. This is 7.9 times the amount in the 1973 published inventory and if included, is 16% of the 1973 total stationary source reactive emissions.

TABLE OF CONTENTS

Page

List of Tables .... *iii*

List of Figures .... *iv*

I. Introduction 1

II. Conclusions 4

III. Recommendations 5

IV. Pesticides 6

V. Emission Assessment 10

VI. Data Search 11

VII. Methodology Development 16

VIII. Work in Progress 28

IX. References 29

Appendix I 1975 Mill-tax Analysis 33

Appendix II Suggested Emission Assessment Procedure 37

Appendix III Application of Methodologies to Kern County .. 40

LIST OF TABLES

Table	Title	Page
1	1974 Agricultural Statistics	14
2	1975 Pesticide Spray Oil Use	18
3	Compilation of Pesticide Use	19
4	1975 PUR Inorganic Pesticides	21
5	1975 PUR Organic Pesticides	22
6	ARB Reactivity Classification or Organic Compounds	25
7	1975 PUR County Totals	26

LIST OF FIGURES

Figure	Title	Page
1	Pesticide Sources and Fates*	7
2	Pesticide Use Reporting Form	9

* Destination in the environment.

I. INTRODUCTION

The Clean Air Act of 1970 mandated establishment, attainment, and maintenance of National Ambient Air Quality Standards (NAAQS). The United States Environmental Protection Agency, formed in response to the mandate and charged to fulfill the requirements of the Act, adopted various air quality standards designed to protect public health and property, and aesthetic values of our environment. The Air Resources Board (ARB) identified areas not meeting the standards and initiated development of State Implementation Plans, which utilize regulatory actions to meet the standards. When it became evident that existing plans would not bring some areas into compliance with the NAAQS by 1985, these areas were designated Air Quality Maintenance Areas (AQMAs) and a strengthened Air Quality Maintenance Planning (AQMP) process was initiated.

In California, the major urban areas (the Los Angeles basin, San Deigo, and the San Francisco Bay Area) and the Central Valley (the San Joaquin and Sacramento Valleys) were given AQMA designation in 1974. The air quality in portions of all of California's AQMAs exceeds or is projected to exceed the 1 hour oxidant standard of 0.08 ppm. [31] Oxidant is therefore a major concern in California. The formation of oxidants in atmospheric photochemical reactions requires quantities of reactive organic gas (ROG), often referred to as hydrocarbon.

One of the early steps which makes possible the formulation of a viable air quality management plan as part of the AQMP process is development of a baseline inventory of all emission sources in each AQMA. Dr. James N. Pitts, Director of the Statewide Air Pollution Research Center at U.C. Riverside, has stated:

> "A comprehensive, detailed, and accurate emissions inventory is _the_ crucial input into any oxidant control strategy. These emissions inventories must be consistent among the interacting local, state, and national control agencies. Otherwise, serious errors may arise in estimating both the absolute and the relative contributions of various sources in a given air basin, and lead to faulty oxidant control strategies." [1]

Motor vehicles and heavy industrial activities are recognized as the major sources of ROG emissions in the urban areas. The ARB and urban air pollution control districts have developed reliable emission factors for these sources. However, these sources are not present in California's Central Valley AQMAs in sufficient quantities to cause the observed oxidant problems. Therefore, the local agencies, charged in the AQMP process to develop the emission inventories, asked the ARB to provide guidance on methodology for assessing ROG emissions from sources such as pesticides. This paper is a response to these requests.

Background knowledge development was necessary to better understand both the emission inventorying process and the pesticide field in general. This background development made it apparent to the author that large quantities of pesticide materials are applied in California for the control of various pests in agricultural, industrial, and home-and-garden situations. Much of this pesticide material is organic, volatile, and reactive. It became apparent that existing emission assessment techniques do not adequately recognize these factors and thus lead to underestimation of reactive organic gas emissions from pesticide use. An investigation was made into available information on various aspects of pesticide emissions. The goal was to obtain factual data to substantiate and quantify the actual emissions. Information was found that illuminates portions of this area of concern, but comprehensive data were not found. Even the factor that seems the firmest, the high volatility of the petroleum oils, is not backed up with specific, accepted, methodical research data.

Several objectives were identified during the course of this study. The overall objective is to improve the methodology for quantifying ROG emissions from pesticide use. Specific objectives include delineating existing methodology, presenting available information, drawing attention to the inadequacies of both the present methodology and available information as well as to the potential magnitude of the actual emissions, developing a preliminary improved assessment technique, and recommending future actions. Within the objectives stated above, the factors to be considered in quantifying reactive organic gas emissions from pesticide usage are separated into three basic categories:

1) Amounts - The amounts of pesticide materials applied have previously been estimated from information presented in the Department of Food and Agriculture's Pesticide Use Report (PUR). [20,21] The PUR, however, reflects only the portions of certain reported applications which are listed in registration applications as being "active ingredients." An "active ingredient" is defined in the Environmental Pesticide Act of 1972 as being "an ingredient which will prevent, destroy, repel or mitigate insects, nematodes, fungi, rodents, weeds or other pests; or accelerate or retard the rate of growth or rate of maturation or otherwise alter the behavior of ornamental or crop plants or the produce thereof." [22] The PUR does not adequately report the amounts of many materials which produce ROG emissions, including those amounts classified as "inert" (not active).

2) Volatility - In the context of organic gas emissions from pesticide use, volatility needs to be defined as the portion, by weight, of the organic material applied that eventually gets into the atmosphere. This includes both the original chemical constituents and all organic chemical

or biological breakdown products, and this also implies a timeframe of up to several years. Petroleum oils are widely utilized in pesticide applications and are categorized both as "active" and as "inert" ingredients. In bulk liquid form these oils have a low volatility. However, after pesticidal application, these oils exist as small airborn droplets and as thin film deposits on plant and soil surfaces. The large surface areas thus presented enhance the volatilization of the petroleum oils. [2,3] In fact, significant residues are not found to remain a long time after application. [30]

3) Reactivity - The reactivity of an organic compound refers here to its ability to participate in photochemical oxidant formation processes. Experts on reactivity seem to be adopting the position that given sufficient time and the right meteorology, all non-methane hydrocarbons (including alcohols, amines, aldehydes, ketones, ethers, glycols, and halogenated hydrocarbons excluding certain perhalogenated compounds) can contribute to photochemical oxidant production. [1,14,28]

This report will consider daily pesticide emissions to be on an annual average basis although it should be recognized that the pesticide materials that they emanate from are not applied on any uniform basis throughout the year. The availability of data on the temporal and spatial disaggregation of pesticide applications will be presented and discussed. Toxicological problems arising from pesticide use are the subjects of concern in other forums and will not be discussed in this report.

II. CONCLUSIONS

1. Pesticides constitute a major source of reactive organic gas emissions. Recommended emission factors make pesticides the largest uncontrolled source of reactive organic gas emissions in agricultural areas.

2. Existing methodology for assessing reactive organic gas emissions from pesticides has underestimated these emissions by a factor of ten or more.

3. Existing data sources provide inadequate information on which to base a reliable assessment of reactive organic gas emissions from pesticides.

4. Methods for assessing reactive organic gas emissions from pesticides which utilize Pesticide Use Report data must adjust for amounts not included in that report.

5. The volatility of substantial amounts of pesticide materials is higher than that used in existing assessment methodology.

6. California pesticide use in 1975 resulted in an estimated 339 tons/day of reactive organic gas emissions. This is 7.9 times the amount in the 1973 published inventory, and if included, is 16% of the total 1973 stationary source reactive organic gas emissions.

7. Considerable additional information on amounts, volatility, and reactivity of pesticides is required in order to generate emission factors with adequate confidence levels.

III. RECOMMENDATIONS

1. The Air Resources Board develop, collect, and evaluate information on amount, volatility, and reactivity of pesticide materials; incorporate the results into revised emission factors; and disseminate.

2. The Air Resources Board and the Department of Food and Agriculture review and incorporate into the existing Pesticide Use Report data processing system available DFA and EPA registration information on "inert" organic constituents.

3. The Department of Food and Agriculture develop appropriate ways to reconcile the mill-tax collection system and the pesticide use reporting system or develop another method to facilitate the generation of a useful, comprehensive and detailed inventory of California's pesticide use.

4. The U.S. Environmental Protection Agency initiate actions to require pesticide manufacturers and formulators to include specifications of "inert" organic ingredients in all registration applications.

5. The Department of Food and Agriculture insure that all applications of pesticides are reported and inventoried.

6. The Air Resources Board utilize information available in the Pesticide Data Bank, Food Protection and Toxicology Center, University of California, Davis, and other sources, to ascertain and evaluate situations where spatial or temporal concentrations of pesticide applications may have significant impacts on air quality.

IV. PESTICIDES

We all have some idea of what pesticides are. Most of us are familiar with the common home insecticide spray can. However, a comprehensive definition seems useful at this point. "A pesticide may be defined as any substance or mixture of substances intended for eliminating or reducing local populations of, or for preventing or decreasing nuisance from, any insect, rodent, fungus, weed, or other form of plant or animal life or viruses, except viruses, micro-organisms, or other parasites on or in living man or animals; and any substance or mixture intended for use as a regulator of plant growth or development, a defoliant or a desiccant, but not materials intended primarily for use as plant nutrients, trace elements, nutritional chemicals, plant inoculants and soil amendments." [27]

Every product intended for use as a pesticide must be registered with the EPA Administrator. Pesticides, determined by the Administrator to present a toxic hazard to the applicator or cause adverse effects on the environment, are classified for restricted use only. Restricted pesticides shall be applied only by or under the direct supervision of a certified applicator, or subject to such other restrictions as the Administrator may provide by regulation. [22] Similarly, California maintains its own list of various restricted pesticides and requires a permit for their possession or use. [23]

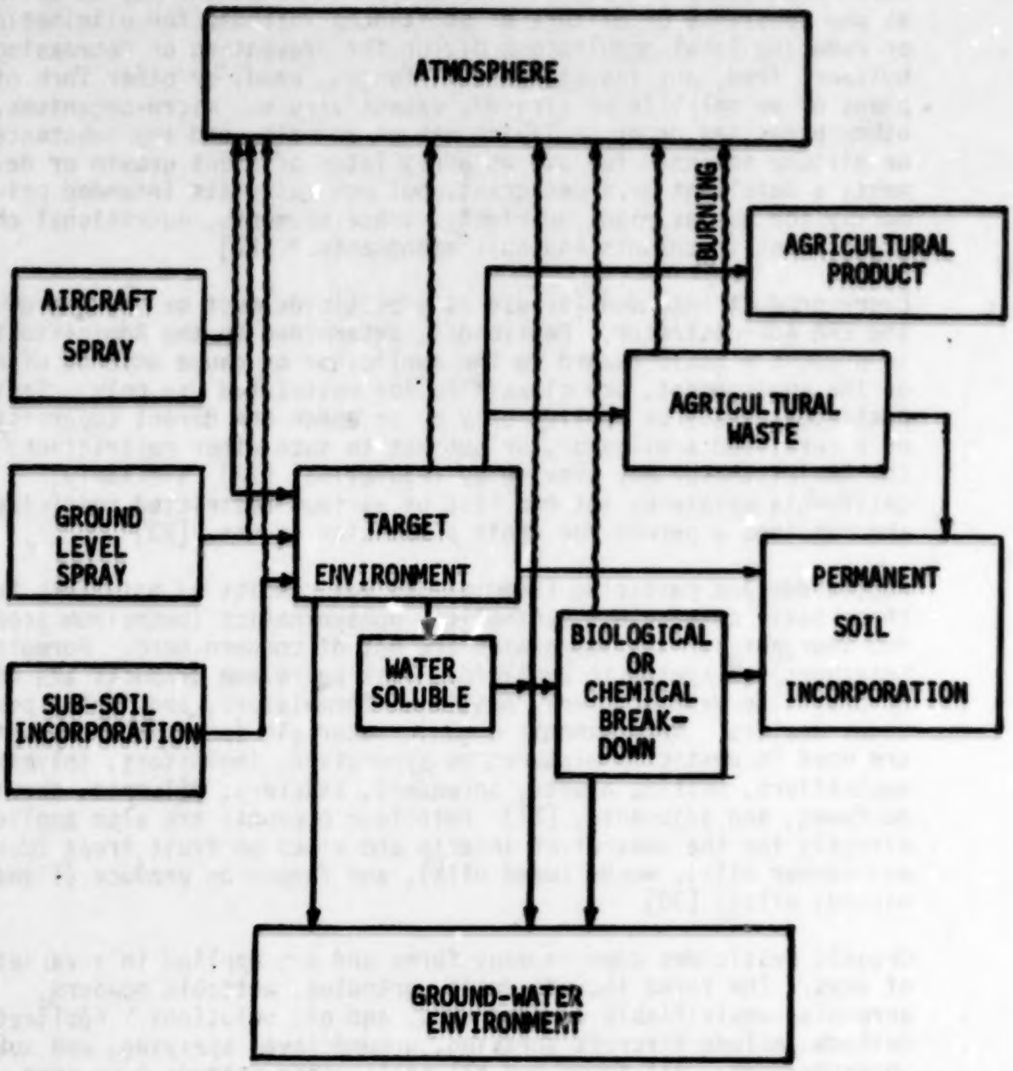
Pesticides and pesticide formulations may consist of materials from three basic categories: synthetics, nonsynthetics (petroleum products), and inorganics. The inorganics are not of concern here. Formulations (mixtures) of synthetic pesticides with petroleum products are made by pesticide manufacturers, pesticide formulators, and lastly pesticides dealers. Nonsynthetic organic materials (petroleum products) are used in pesticide mixtures as synergists, inhibitors, solvents, emulsifiers, wetting agents, spreaders, stickers, diluents, carriers, perfumes, and adjuvants. [27] Petroleum products are also applied directly for the control of insects and mites on fruit trees (dormant and summer oils), weeds (weed oils), and fungus on produce (light mineral oils). [30]

Organic pesticides come in many forms and are applied in a variety of ways. The forms include dusts, granules, wettable powders, aerosols, emulsifiable concentrates, and oil solutions. Application methods include aircraft spraying, ground-level spraying, and sub-soil incorporation. All forms and all application methods have some potential for volatile emissions.

Once the pesticide materials have been applied, various processes and factors determine their ultimate fate in the environment. The second law of ecology states: "Everything goes somewhere." A proper analysis of organic emissions from pesticide applications must consider all of the pathways. Figure 1 shows the various types of

Figure 1

PESTICIDE SOURCES AND FATES


ATMOSPHERE
BURNING
AGRICULTURAL PRODUCT
AIRCRAFT SPRAY
AGRICULTURAL WASTE
GROUND LEVEL SPRAY
TARGET ENVIRONMENT
PERMANENT SOIL INCORPORATION
WATER SOLUBLE
BIOLOGICAL OR CHEMICAL BREAK-DOWN
SUB-SOIL INCORPORATION
GROUND-WATER ENVIRONMENT

applications and fates of pesticide materials. The fates which affect the ambient air environment include evaporation before and after reaching the target environment, co-evaporation with water evapo-transpiration, volatilization of biological and chemical breakdown products, and evaporation from and burning of agricultural waste.

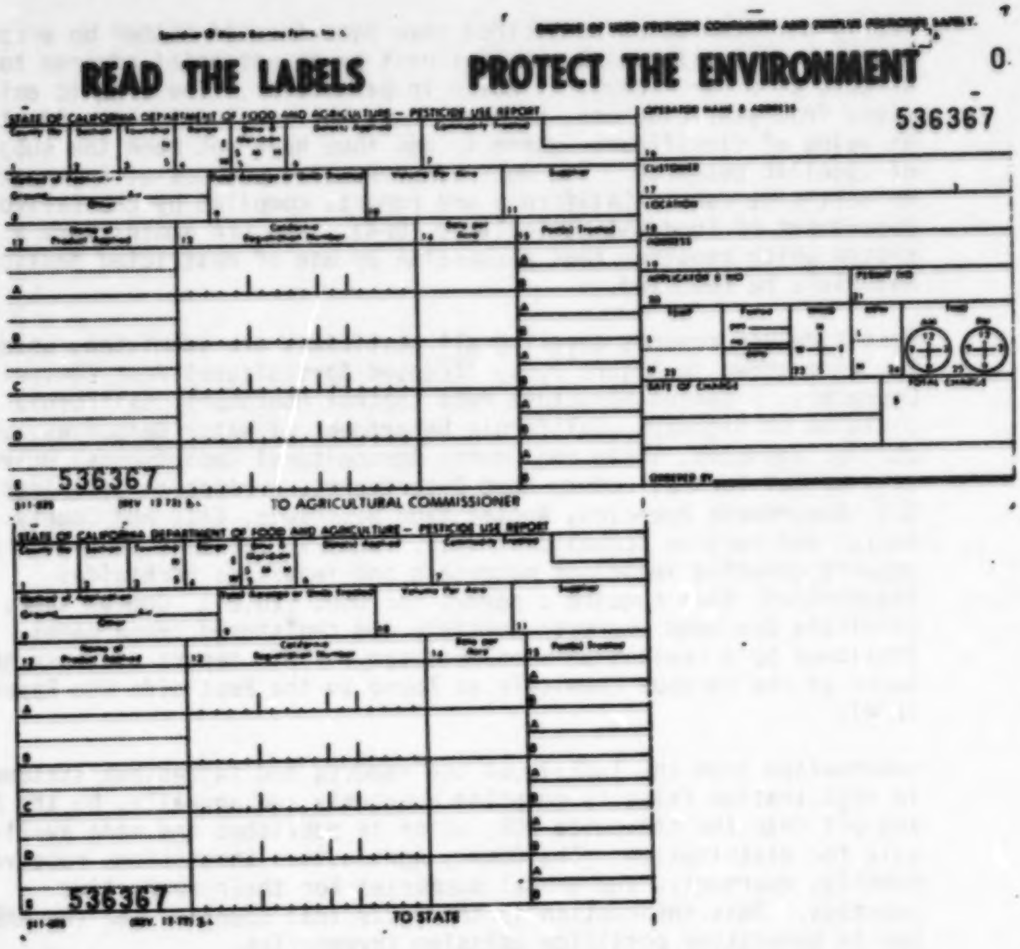
Nearly all studies of pesticides have been focused either on effectiveness in dealing with a target pest or on potential adverse toxic effects on other receptors, human in particular. The organic emissions from pesticide use, however, have not previously been identified as being of significant interest, and thus have not been the subject of specific research. The most comprehensive sources of information on pesticide use in California are reports compiled by the California Department of Food and Agriculture (DFA). The DFA administers a system which requires that possession or use of restricted pesticide materials be reported.

Pesticide use reports covering all pesticides are submitted, using the form shown in Figure 2, by licensed Agricultural Pest Control Operators, licensed Structure Pest Control Operators, California Division of Highways, California Department of Water Resources, vector control agencies, State and County Agricultural Departments, University of California, County Road Departments, Irrigation Districts, U.S. Government Agencies, Reclamation Districts, City and County Parks, and various school districts. Reports are also submitted by growers covering injurious materials and injurious herbicides (restricted) that require a permit for use. [20,21] Common names of chemicals are used wherever possible and registered brand names (followed by a capital R) when necessary. This report will use the names of the various chemicals as found in the Pesticide Use Report (PUR).

Information from the individual use reports and ingredient statements in registration files is compiled quarterly and annually, by the DFA, and put into the statewide PUR, which is published and made available for distribution. The County Agriculture Commissions receive monthly, quarterly, and annual summaries for their respective counties. This information is the basis that counties and the ARB use in generating pesticide emission inventories.

Figure 2

PESTICIDE USE REPORT FORM



DISPOSE OF USED PESTICIDE CONTAINERS AND SURPLUS PESTICIDES SAFELY.

READ THE LABELS PROTECT THE ENVIRONMENT

STATE OF CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE – PESTICIDE USE REPORT

OPERATOR NAME & ADDRESS 536367

CUSTOMER

LOCATION

ADDRESS

APPLICATOR & NO

PERMIT NO

DATE OF CHARGE

TOTAL CHARGE $

CHECKED BY

A

B

C

D

E 536367

TO AGRICULTURAL COMMISSIONER

STATE OF CALIFORNIA DEPARTMENT OF FOOD AND AGRICULTURE – PESTICIDE USE REPORT

A

B

C

D

E 536367

TO STATE

V. EMISSION ASSESSMENT

A draft statewide inventory of all 1972 air pollution emissions was compiled by the Air Resources Board (ARB) during fiscal year 1972-73. Pesticide Use Report (PUR) data on reported amounts of active ingredients applied in each county are the basis for the assessment of pesticide emissions in this inventory. It divides the organic materials found in the PUR into two groups. The first group consists of petroleum distillates, petroleum hydrocarbons, petroleum oil unclassified, and mineral oil. This group is considered to be 10% volatile. The second group consists of aromatic petroleum solvents, xylene, xylene range and all other liquid or gaseous organics (at 70° F.) (including D-D mixture, DBCP, Telone-R, Phorate, Chloropicrin, Methyl Bromide, Malathion, Parathion, Ordram-R and Diazinon). This group is considered to be 90% volatile. The amounts found in the first group, multiplied by 0.1, and the amounts found in the second group, multiplied by 0.9, are added together and reported as total hydrocarbons (HC). This HC figure is multiplied by .8 (an assumed reactivity factor) and the result is reported as high reactive (HR). [4]

The ARB subsequently made an inventory for the year 1973 which has been published. [5] In this inventory, the 1972 total HC figure for each county is multiplied by the ratio of total 1973 pesticide applications to total 1972 pesticide applications (from the 1972 and 1973 county PUR data). The result is reported as 1973 total organic gas (TOG). [5] The same number is reported as reactive organic gas (ROG) in light of the then recent ARB reactivity classification scheme. (See Table 6.) In equation form, the pesticide emissions correction from calendar 1972 to 1973 is:

$$1972\ \text{HC} \times \frac{1973\ \text{PUR}}{1972\ \text{PUR}} = 1973\ \text{TOG} = 1973\ \text{ROG}$$

In short, the methodologies used in generating the 1972 and 1973 statewide emission inventories differ only in their assessment of reactivities. A shortcut was employed in arriving at the numbers reported in the 1973 inventory, but the underlying perception of what was being inventoried remained the same. These methodologies and this perception comprise the existing ARB assessment of reactive organic gas emissions from pesticides.

VI. DATA SEARCH

In the course of evaluating the existing emission assessment methodology, the author noted that the Pesticide Use Report (PUR) reflects only the amounts of active ingredients contained in reported applications. This raised two questions: What are the "inactive ingredients" and are all applications reported? These questions lead to the Department of Food and Agriculture (DFA) so there they were raised.

The answer to the first question was found in the file of registration applications. Many ingredient-statements list substantial amounts of nonsynthetic organic materials, including xylene and other petroleum products, as "inerts." The amounts of "inert" organic materials associated with applications of these formulations do not get into the PUR and thus are not reflected in existing ARB emission inventories.

The answer to the second question, "are all applications reported?", was that the DFA feels that the PUR reflects 80% of the amounts of applications which require reporting. The missing 20% is felt to consist of a combination of two factors; 1) applications required to be reported but not, and 2) applications for which the reported numbers are rejected by the computer due to transposed digits or some other procedural error. No substantiation for the 80% figure has been offered. [6]

The results of the initial investigation did not build up confidence in existing ARB pesticide emission assessment methodology. Substantial amounts of organic materials are not getting into the inventory. It was apparent that more investigation would be required. It was not apparent what results of the investigation would be.

A series of telephone calls was initiated to those who might be able to lend expertise to the search for information. It was, of course, necessary to describe the particular area of interest of the investigation--emissions of reactive organic gas--as well as what had already been discovered. The information found in the preliminary investigation, both on existing ARB emission assessment methodology and the PUR, was shared and questions were asked. Findings common to all such conversations were that the aspect of concern in the investigation had not previously been significantly raised, there was a feeling of welcoming this concern, and nearly all of the contacts had some useful information to share.

Dr. Crosby, at U.C. Davis, soon focused on one facet of the existing ARB methodology: the volatility of the petroleum oils. [44] The existing ARB methodology assigns these materials a 10% volatility factor. Dr. Crosby questioned this low volatility and suggested that it be examined very carefully. He considers the petroleum oils to be highly volatile in pesticidal applications. An example of a similar material was offered: jet fuel, a petroleum product similar to kerosene which is ordinarily considered to have a low volatility, is frequently dumped in flight by military aircraft. None of the jet fuel reaches the ground. The liquid organic material breaks up into fine droplets which increases volatility. Petroleum products exist, during and after pesticidal application, as droplets or thin films. The resultant high surface area causes an increase in volatility. Petroleum products constitute nearly 50% of the organic materials in the PUR. Recognizing the high volatility of the petroleum products signifies a large change in any assessment of pesticide emissions.

Considerable further research was now seen to be necessary with the potential impact being a substantial increase in inventoried ROG emissions from pesticides.

The PUR system is the only available source of data on actual pesticide applications in California. The availability of data for each county is particularly useful. The requirements for grower reporting of restricted materials and governmental agencies reporting of all materials, which provide input into the PUR, are described in Section IV.

Exemptions, which relieve the applicator of the reporting burden, include: home, structural, industrial, and institutional uses of certain specific materials; certain dilute formulations; and certain small package sizes of other specified materials. [23] In addition, unlicensed individuals are not required to report applications of unrestricted materials. The unrestricted category includes weed oils: both materials sold and labeled as weed oil, and other materials utilized as weed controls. The applications covered by the reporting exemptions and thus not reported, the misreporting and non-reporting of applications requiring reporting, and the deletion of "inert" materials in the compilation of the PUR combine to result in the PUR showing only a fraction of the amounts of organic materials actually applied.

The DFA collects an assessment on all California pesticide sales. The assessment (referred to as the mill-tax) is 0.8¢ (8 mill) per dollar, based on the price charged in the final sale by the registrant. 1975 mill-tax revenues were collected on sales of $326,000,000. [32] Unfortunately, the DFA monitors neither prices nor sales quantities. The author has put together the analysis in Appendix I, assigning price estimates to various pesticide categories and varying the distribution of amounts in the categories to obtain an estimate of the amounts of pesticides sold. The analysis shows the amounts of organic pesticide materials sold in California to be several times those found in the PUR.

The EPA Region IX Producer Establishment File shows weed oil production in California in 1975 to be 75,700,000 lb. [41] Nearly all of this was for sale in California. Application of this material is seldom reported to the DFA and thus the 75 million lb. must be added to the 34.5 million lb. of nonsynthetic organics listed in the 1975 PUR.

The U.S. International Trade Commission reports 1975 U.S. synthetic organic pesticide sales of 1,328,360,000 lb. [7] This does not include nonsynthetic organics such as petroleum oils, petroleum hydrocarbons, petroleum distillates, aromatic petroleum solvents, xylene and weed oil. Pesticide use in California has been estimated as 20% of national use, but there is no direct information to verify this estimate. Statistics shown in Table 1 indicate that California accounts for 11.39% of U.S. agricultural crop production in 1974. Assuming pesticide use in proportion to agricultural production, California's portion of U.S. 1975 synthetic organic pesticide sales would be 133 million lb. This is 3.4 times the 39.5 million lb. of synthetic organic pesticides shown in the PUR. Actually the California and U.S. agricultural statistics show more intensive agricultural production in California - 11.39% of U.S. crop production from 2.4% of U.S. crop acreage. More intensive production may imply more intensive pesticide use.

Specific information on the volatility of either the synthetic or nonsynthetic organic pesticides was not found. The nonsynthetic materials do not leave significant residues and thus seem to be highly volatile. The Petroleum Processing Handbook, describing the historical development of pesticides, implicity recognizes the high volatility of petroleum oils in the following description of the action of residual spray: "This consisted of a solution of a stable active toxic chemical in a petroleum-base oil. When the oil evaporates [emphasis added], a film of insecticide remains..." [30] A typical residual spray formulation contains 5% DDT, 15% aromatic petroleum solvent and 80% deodorized kerosene. [30] There is no reason to expect other combinations of toxicants and petroleum oils to not evaporate in similar fashion.

The synthetic organic pesticides are subject to chemical and biological breakdown. They are, however, rapidly volatilized if they possess significant vapor pressures and are not held to foliage surfaces by leaf waxes or pores. [33]

The reactivity of the nonsynthetic organics can be confidently assigned to the moderate and high reactivity categories (ARB classes II and III). Specifications of unsaturation and aromatic composition are required for more accurate differentiation between classes II and III. (See Table 6.) Results of specific research on photochemical reactivity were found on only a few of the synthetic organic pesticides. [14-16] While similar materials may be concluded to have similar reactivities, the reactivity classification of many

Table 1

1974 Agricultural Statistics

[38,39]

	U.S.	California	Cal %
Farm acres	1,021,025,063	33,385,619	3.28
Crop acres	437,823,936	10,579,277*	2.42
Value of agricultural product sold including livestock and forest products	$80,425,896,000	7,399,623,000	9.16
Value of crops including nursery and hay	$41,221,500,000	4,730,855,000	11.39

* preliminary

synthetic organic pesticides can only be inferred. The synthetic organic pesticides tend to be very large molecules; and the reactivity of many families tends to increase with size. Classifying these pesticides by family grouping seems to be a conservative approach.

The results of the data search show larger amounts of pesticide material than presently inventoried by the ARB. The results also show a much higher volatility for the largest category, the nonsynthetics, which includes the large amounts not being inventoried. Reactivity information is less crucial, but is needed for provision of an inventory of the highest accuracy.

Emission inventories commonly report emissions in tons per day, calculated by dividing annual emissions by 365. The reporting of a daily emission figure should not be assumed to imply uniform temporal or spatial distribution of emissions. In reality the emissions may occur at various times and are seldom uniformly distributed. Pesticide applications are concentrated in certain areas, at certain times of the day, and during certain seasons. Some of the applications may indeed be random, but they will never be uniform. The PUR system records the specific time and place of application. (See Figure 2.) The PUR data base will thus be useful in cases where knowledge of temporal or spatial disaggregation is desired.

VII. METHODOLOGY DEVELOPMENT

Observed discrepancies between existing emission inventories and the information presented here indicate a need for development of better pesticide use data and emission factors. The current need for baseline emission inventories for AQMP consideration requires development of interim factors reflecting the best available information. Additional information on local pesticide use, volatility, or reactivity will be carefully considered by ARB staff.

Despite it's shortcomings, the Pesticide Use Report (PUR) is still the most useful source of pesticide use data. Correction factors are necessary to adjust reported use rates to reflect unreported pesticide use. These correction factors are obtained by considering several data and estimates. While any one of these data or estimates may be challenged, the general agreement between them and the absence of contradictory information leads to their use at this time. The amounts of both synthetic and nonsynthetic organic pesticides called for in the following estimates are compiled in Table 3.

1. The State Department of Food and Agriculture (DFA) indicates that the PUR reflects 80% of the active ingredients from pesticide applications requiring reporting. [6]

2. Confidential information was obtained from a major producer on their inert organic ingredient output. This amount divided by their reported active organics is 25%. A Kern County agricultural expert estimates that 75% of the organic pesticide applications are emulsifiable concentrates at 45-50% average inert organic concentration. This estimate (.75 X .45 = .34) indicates that 25% is conservative. Pesticide formulators and dealers commonly dilute the product (add inert ingredients) for safety and convenience. Knowledge of this situation adds confidence to the conservatism of using the 25% concentration figure.

3. Applications of weed oils or similar materials such as diesel oil or kerosene are seldom reported. Licensed applicators and government agencies which would report such use, instead use more economically-effective synthetic herbicides. Private individuals, however, do not need a permit to apply weed oils; so these applications are not reflected in any use report. Materials sold as weed oil amount to 9,832,380 gallons (75,700,000 lb.). [41]

4. Establishments are known to sell nonspecific organics which are used as weed oils. Substantial additional amounts of petroleum products are used as insecticides. These uses include summer oils, dormant oils, and carrot oils. In addition, cresote, a coal tar product, is used to prevent insects from attacking wood. Most of the use of these nonsynthetic organics is not

reported to either the DFA or the EPA. A compilation of California fruit and nut acreage, with dormant oil application rates suggested by University of California and county Agriculture Commission experts, shows 66 million pounds of dormant oil applied in 1975. (See Table 2.) If the crankcase drainings from 5% of California's automobile population are applied to control weeds; this would amount to 4.5 million pounds (assuming four quarts drained twice per year). Approximately 85 million pounds of cresote were used in 1972 in California, Nevada, Arizona, and New Mexico for preserving wood from attack by fungi, marine borers, and insects. [25] If 10% of California's portion (58 million pounds) is eventually volatilized, this amount to nearly 6 million pounds. These estimates add up to approximately 76 million pounds which is used in this analysis.

5. Pesticides and associated inerts used for home-and-garden and many commercial and industrial applications are not covered by the PUR. Estimates of nonagricultural use range from 20-50% of total applications. The EPA estimated in 1974 that 41% of the active-ingredient pesticides in the U.S. are used in nonagricultural situations. [25] An estimate of 35% is used here.

6. Dr. Jarad Abell, head of the Formulation Research Group at Chevron Chemical in Richmond, California suggested an average active ingredient concentration of 1% be used for home-and-garden pesticide aerosol cans. He also suggested an average inert organic concentration of 20% be used (20 times the active ingredient amount). [35] USDA statistics give 1974 U.S. production of pesticide presurized spray containers of 125,411,000. [37] Assuming sales on a per capita basis and assuming California's population to be 10% of the U.S. population results in an estimate of 12.5 million cans in California in 1975. Dan Hogan, national marketing manager for Chevron Chemical, stated that the average aerosol spray can contains 14 oz. of product. He also stated that 11.7% of their home-and-garden business (by units) was the aerosol spray can (assumed to be indicative of the industry average). [36]

7. The remaining 88.3% of the home-and-garden as well as additional industrial-commercial products are assumed to have average concentrations of 25% active ingredients and 25% inert organics (suggested by both Dr. Abell and Mr. Hogan). [35,36]

Table 3 shows the amounts of both synthetic and nonsynthetic pesticides called for in the above estimates. The total amounts in both categories are divided by the totals reported in the 1975 PUR to obtain suitable multiples or correction factors.

Table 2

1975 INSECTICIDE SPRAY OIL USE - ONE ANNUAL APPLICATION ON TOTAL ACREAGE

CROP	ACRES [45]	RATE (lb./acre)	AMOUNT (lb.)
Almonds (So. SJQV)	163,518 (76)	45*	7,358,310
Apples	26,807	45*	1,206,315
Apricots	31,117	45*	1,400,265
Avocados	40,588	45*	1,826,460
Cherries	13,980	45*	629,100
Figs	18,754	45*	843,930
Grapes	248,850	7**	1,741,950
Grapefruit	25,998	175***	4,549,650
Lemons (So. Cal.)	51,226 (76)	350*** (2 applic.)	17,929,100
Limes (So. Cal.)	463 (76)	175***	81,025
Nectarines (So. Cal.)	18,230 (76)	175***	3,190,250
Oranges (So. Cal.)	65,453	175***	11,454,275
Peaches	88,738	45*	3,993,210
Pears	41,612	45*	1,872,540
Persimmons (76)	570	45*	25,650
Pistachios	29,727	45*	1,337,715
Plums	31,203	45*	1,404,135
Pomegranates (76)	2,958	45*	133,110
Prunes	87,018	45*	3,915,810
Tangelos (So. Cal.)	2,081 (76)	175***	364,175
Tangerines (so. Cal.)	3,138 (76)	175***	549,150
Tangors (So. Cal.)	907 (76)	175***	158,725
			65,964,850

* [46]
** [47]
*** [48]

Table 3

COMPILATION OF 1975 PESTICIDE USE

		Synthetics	Nonsynthetics
	1975 PUR	39,070,838 lb.	34,547,690 lb.
1.	Reporting Errors ($\frac{.20}{.80}$ = .25) =	9,767,710 lb.	8,636,923 lb.
2.	Inerts (+25% of 75 PUR organics) =		18,404,633 lb.
3.	Specific Weed Oils =		75,700,000 lb.
4.	Nonspecific Organics =		76,000,000 lb.
	Subtotal	48,838,548 lb.	213,304,356 lb.
5.	Nonagricultural: (35%)		
	Home and Garden:		
6.	Aerosol Cans - (12.5 X 10^6)(14oz X .01) =	109,375 lb.	
	(X .20) =		2,187,500 lb.
7.	Other (12.5 X 10^6 X $\frac{.883}{.117}$ X .25) =	23,575,000 lb. =	23,575,000 lb.
	Industrial & Commercial: (remainder of 35%)	2,613,305 lb.	2,613,305 lb.
	TOTAL	75,136,228 lb.	241,680,161 lb.

75 PUR multiple--correction factors:

Synthetics: $\frac{75,136,228}{39,070,838}$ = 1.92

Nonsynthetics: $\frac{241,680,161}{34,547,690}$ = 7

Table 4 shows the amounts of inorganic pesticides found in the 1975 PUR. This list may be useful in identifying the major inorganics for those compiling emission inventories.

Table 5 shows the amounts of both nonsynthetic and synthetic organic pesticides found in the 1975 PUR. Table 5 also contains preliminary assignments of volatility and reactivity to assist those compiling emission inventories. The assignments for the nonsynthetics are reasonably conclusive with the exception that amounts of unsaturation and aromatic content in the petroleum products will be class III. (See Table 6.) The volatility and reactivity of the synthetics are highly conjectural and are presented only in the lack of better information.

The application of the correction factors from Table 3 and the volatility and reactivity factors from Table 5 to the 1975 PUR data results in an estimate of 1975 statewide pesticide organic emissions of 347 tons/day. Of this, 339 tons/day are reactive. This latter figure is 7.9 times the amount in the 1973 published inventory and if included, is 16% of the total 1973 stationary source ROG emissions. [5]

It must be emphasized that the correction factors in Table 3 are based on statewide information. Use caution when applying these factors to areas with urban and agricultural distributions significantly different from the statewide distribution.

Table 4

1975 PUR Inorganic Pesticides

Pesticides > 100,000 lb.	Statewide Applications
Blue vitriol	430,777 lb.
Copper hydroxide	186,446 lb.
Copper oxychloride sulfate	362,153 lb.
Copper sulfate (basic)	421,167 lb.
Copper-zinc sulfate complex	176,377 lb.
Cryolite	548,206 lb.
Disodium octaborate tetrahydrate	376,976 lb.
Magnesium Chloride	360,344 lb.
Sodium Chlorate	1,824,229 lb.
Sulfur	25,612,672 lb.
Sulfuric acid	112,090 lb.
Vikane-R	133,002 lb.
TOTAL	30,544,439 lb.
% of 75 PUR total	28.98%

Table 5

1975 PUR Organic Pesticides

Pesticides > 100,000 lb.	Statewide Reported Active Ingredient Applications	% of Organics	Volatility	Reactivity
Aldicarb	194,218 Lb.	.26%		
Amitrole	109,820	.15		
* Aromatic Petroleum Solvents	3,226,856	4.38	90%	III
Atrazine	120,840	.16		
Azodrin-R	220,711	.30		
Benomyl	100,468	.14		
Captan	207,710	.28	10%	III
Carbaryl	1,002,351	1.36	10%	III
Carbofuran	123,748	.17		
Chlordane	697,244	.95		
Chloropicrin	1,902,148	2.58	90%	III
Chlorothalonil	227,642	.31		
2, 4-D	169,582	.23	90%	III
2, 4-D, Alkanolamine salts (Ethanol and Isopropanol amines)	352,589	.48		
2, 4-D, Dimethylamine Salt	426,748	.58	10%	III
2, 4-D, Propyleneglycolbutylether ester	805,281	1.09	90%	III
Dacthal-R	307,943	.42		
Dalapon, Sodium Salt	276,767	.38		
DBCP & other related	634,237	.86	90%	I
D-D mixture	3,176,866	4.32	10%	III

* Non-synthetics

Table 5
Cont.

DEF	426,754	.58	90%	III	
Diazinon	309,413	.42	90%	III	[33]
Difolatan-R	564,549	.77			
Dimethoate	473,685	.64	90%		
Diphenamid	144,910	.20			
Di-syston-R	432,626	.59			
Dithane	189,982	.26			
Diuron	235,992	.32			
DNBP	1,742,021	2.37	50%	III	
Dylox-R	137,566	.19			
Endosulfan	471,080	.64			
Ethion	196,398	.27			
Ethylene Dibromide	407,250	.55	5%	I	[24]
Fundal-R	144,965	.20			
Guthion-R	316,305	.43			
IPC (Isopropyl Carbanilate)	240,539	.33	90%	III	
Kelthane-R	508,939	.69	10%	III	[34]
Malathion	455,209	.62	90%	III	[34]
Maleic Hydrazide, Diethanolamine Salt	151,581	.21			
Maneb	230,539	.31			
MCPA, Dimethamine Salt	382,612	.52			
Methomyl	854,402	1.16	90%	III	[34]
Methyl Bromide	7,164,325	9.73	(acres) 20% (Other) 75%	I	[24]

Table 5
Cont.

Methyl Parathion	494,305	.67	90%	III	[10,34]
* Mineral Oil	1,996,425	2.71	90%	II	
Naled	238,978	.32			
Omite-R	641,988	.87	90%	III	[34]
Ordram-R	962,323	1.31	90%	III	
Paraquat Dichloride	393,403	.53			
Parathion	912,517	1.24	90%	III	[10]
* Petroleum Distillates	2,063,457	2.80	90%	II	
* Petroleum Distillate, Aromatic	146,999	.20	90%	III	
* Petroleum Hydrocarbons	9,115,721	12.38	90%	II	
* Petroleum Oil, unclassified	16,426,963	22.31	90%	II	
Phorate	548,012	.74	90%	III	[29,33,34]
Phosdrin-R & other related	272,294	.37			
Simazine	252,509	.34			
Sodium Cacodylate	207,033	.28			
Telone-R	1,365,512	1.85	10%	III	
TOK-25-R	178,466	.24			
Toxaphene	1,004,444	1.36	50%	III	
Trifluralin	151,059	.21	90%	III	[10]
* Xylene	1,177,534	1.60	90%	III	
* Xylene Range	393.735	.53	90%	III	
Ziram	145,888	.20			
TOTAL	69,554,976 lb.	94.48%			
PUR total	104,163,067 lb.				
-inorganics>1000 lb.	30,544,439 lb.				
PUR organic total	73,618,528 lb.				

Table 6

ARB
REACTIVITY CLASSIFICATION OF ORGANIC COMPOUNDS

Class I (Low Reactivity)	Class II (Moderate Reactivity)	Class III (High Reactivity)
C_1-C_2 Paraffins	Mono-tert-alkyl-benzenes	All other aromatic hydrocarbons
Acetylene	Cyclic Ketones	All Olefinic hydrocarbons (including partially halogenated)
Benzene	Alkyl acetates	Aliphatic aldehydes
Benzaldehyde	2-Nitropropane	Branch alkyl Ketones
Acetone	C_3+ Paraffins	Cellosolve acetate
Methanol	Cycloparaffins	Unsaturated Ketones
Tert-alkyl alcohols	N-alkyl Ketones	Primary & secondary C_2+ alcohols
Phenyl acetate	N-methyl pyrrolidone	Diacetone alcohol
Methyl benzoate	N,N-dimethyl acetamide	Ethers
Ethyl Amines	Alkyl Phenols*	Cellosolves
Dimethyl formamide	Methyl phthalates**	Glycols*
Perhalogenated Hydrocarbons		C_2+ Alkyl phthalates**
Partially halogenated paraffins		Other Esters**
Phthalic Anhydride**		Alcohol Amines**
Phthalic Acids**		C_3+ Organic acids + di acid**
Acetonitrile*		C_3+ di acid anhydrides**
Acetic Acid		Formin** (Hexa methylene-tetramine)
Aromatic Amines		Terpenic hydrocarbons
Hydroxyl Amines		Olefin oxides**
Naphthalene*		
Chlorobenzenes*		
Nitrobenzenes*		
Phenol*		

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* Reactivity data are either non-existent or inconclusive, but conclusive data from similar compounds are available; therefore, rating is uncertain but reasonable.

** Reactivity data are uncertain

Table 7

Annual 1975 PESTICIDE USE REPORT COUNTY TOTALS

		APPS.	POUNDS	ACRES
	GRAND TOTAL	443,263	104,163,067.38	25,290,146.80
ACTUAL APPLICATIONS-	AGRICULTURAL	230,828	93,306,636.36	16,042,873.44
	STRUCTURAL		981,244.40	
	GOVERNMENTAL		6,188,716.14	
	TOTAL	230,828	102,476,596.90	16,042,873.44
ACTUAL ACRES TREATED-	AIR	9,968,408.18		
	GROUND	4,208,096.15		
	OTHER	246,075.94		

COUNTY	APPS.	POUNDS	ACRES
ALAMEDA	729	517,159.76	16,916.85
ALPINE	4	3,048.93	690.00
AMADOR	59	19,322.09	2,335.00
BUTTE	3,649	1,299,388.55	329,472.58
CALAVERAS	62	17,545.94	1,429.20
COLUSA	3,805	1,103,990.38	467,943.90
CONTRA COSTA	1,471	554,113.52	57,518.90
DEL NORTE	31	3,200.31	1,132.00
EL DORADO	156	44,356.30	1,785.44
FRESNO	22,583	8,631,635.41	1,910,301.41
GLENN	2,447	814,135.01	295,004.16
HUMBOLDT	21	30,194.11	1,937.00
IMPERIAL	25,638	7,251,129.79	2,010,159.76
INYO	5	1,785.47	821.00
KERN	12,934	6,886,390.28	1,375,478.11
KINGS	5,839	2,046,905.76	878,413.90
LAKE	772	159,161.24	24,920.60
LASSEN	73	13,305.91	8,035.00
LOS ANGELES	1,003	1,633,672.86	63,430.61
MADERA	4,458	4,057,147.76	349,735.40
MARIN	16	826,954.37	3,922.31
MARIPOSA	9	3,106.87	110.55
MENDOCINO	894	249,193.14	29,841.10
MERCED	7,317	6,565,339.99	471,313.49
MODOC	801	76,579.33	52,862.90
MONO	8	2,976.63	783.23
MONTEREY	27,498	7,250,616.46	737,995.51
NAPA	812	479,257.45	39,342.16
NEVADA	40	23,757.28	1,459.00
ORANGE	1,193	1,126,869.32	34,058.43
PLACER	473	103,061.51	30,480.60
PLUMAS	5	1,706.45	423.50
RIVERSIDE	9,264	2,920,716.50	509,736.69
SACRAMENTO	2,590	1,248,571.31	231,528.44

Table 7 cont.

Annual 1975 PESTICIDE USE REPORT

COUNTY	APPS.	POUNDS	ACRES
SAN BENITO	2,355	538,296.12	77,199.76
SAN BERNARDINO	2,269	1,153,118.08	60,951.81
SAN DIEGO	2,458	1,231,241.55	67,773.47
SAN FRANCISCO	4	33,606.74	177.00
SAN JOAQUIN	12,741	9,546,006.73	611,759.96
SAN LUIS OBISPO	4,559	802,224.62	126,378.55
SAN MATEO	405	140,929.40	6,379.16
SANTA BARBARA	9,553	2,450,162.73	198,208.26
SANTA CLARA	1,677	760,270.05	45,870.79
SANTA CRUZ	3,288	1,448,099.63	67,931.30
SHASTA	175	219,627.14	8,038.47
SIERRA	3	2,228.07	659.00
SISKIYOU	880	78,960.17	65,998.06
SOLANO	3,114	1,551,356.63	221,442.40
SONOMA	1,656	468,577.77	57,255.88
STANISLAUS	8,877	8,840,352.85	433,598.16
SUTTER	5,253	1,836,737.91	460,985.23
TEHAMA	719	409,318.38	45,648.33
TRINITY	2,414	11,822.39	541,968.45
TULARE	12,974	2,831,110.81	1,826,174.86
TUOLUMME	128	8,160.84	4,897.00
VENTURA	11,574	8,542,765.02	276,096.43
YOLO	5,850	2,709,573.16	571,971.10
YUBA	1,223	667,731.66	104,171.19
TOTAL	230,628	102,476,596.90	16,042,873.44

VIII. WORK IN PROGRESS

1. Eureka Laboratories is studying emissions from pesticide applications in Fresno County and is expected to submit a final report to the ARB and EPA by June 1978.

2. Work is being undertaken by KVB, in the South Coast Air Basin, to obtain data on nonagricultural applications (home-and-garden and industrial).

3. The DFA Environmental Assessment Team is in the process of researching and compiling information on pesticide use and the resultant impact, primarily aimed at toxicological concerns. The results of this significant effort, in combination with the ARB's emission inventory work, can be expected to focus considerable attention on the various environmental impacts of pesticide use.

4. A major revision of the ARB Emission and Air Quality Assessment report is being undertaken which will include an updating of the pesticide emission assessment methodology and data.

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APPENDIX I

1975 Mill-Tax Analysis

The State Department of Food and Agriculture (DFA) collected an assessment on total 1975 California pesticide sales of $326 million. This seems to be most comprehensive source of sales information since all pesticide sales are assessed. The DFA does not monitor either prices or quantities sold so the total sales figure is not useful directly. If pricing can be obtained, the total quantities sold can be calculated. To do this, it is necessary to divide pesticides into synthetic, nonsynthetic, and inorganic categories as these categories have radically different price structures.

The aggregate wholesale price of the synthetic organics sold nationally in 1975 was $1.78 per lb. [7] Ivan Smith of the Western Agricultural Chemicals Association says the typical mark-up in the pesticide industry is 10 percent. [40] Since there are usually two levels of price increase (a double 10 percent mark-up), $2.15 lb. is chosen for this analysis.

Consulting the July 7, 1975 Chemical Marketing Reporter and retail outlets leads to assigning an aggregate retail price of 10 cents per lb. (77 cents per gallon) to the nonsynthetic category (petroleum products) and 15 cents per lb. to the inorganic category (mostly sulfur).

Calculating the total sales quantity, using the proportions found in the Pesticide Use Report (PUR) for the three categories, results in a total of 365 million lb. The synthetic and nonsynthetic PUR multiple correction factors would both be 3.5.

The PUR system is primarily designed to report the use of restricted materials which are composed largely of the synthetics. It seems reasonable to postulate, therefore, that the synthetics are more heavily represented in the PUR than in actual sales. Developing this insight, the following analysis varies the percentage assigned to the synthetic category and shows the resulting quantities of all three categories. The relative amounts of the nonsynthetics and inorganics are fixed at the proportions found in the PUR to avoid having excess unknowns. The higher price of the synthetics results in much larger totals for smaller synthetic percentages.

The mill-tax is not collected on the petroleum products not specified or sold as pesticides. Therefore, this analysis does not reflect the amounts of nonspecific organics used as pesticides. (See Section VII, Item 4.)

The results of this analysis are shown in the following tables and graph. The estimates in Section VII and Table I are consistent with the mill-tax analysis.

Chemical Commodity Prices from July 7, 1975 Chemical Marketing Reporter
(Quotation of list prices)

		$/lb.
Sulfur, crude	$53-58.5/long ton	.03
Sulfur, flour, light	$11.25/100 lb.	.11
Sodium metaborate, octahydrate	$140/ton	.07
Sodium metaborate, tetrahydrate	$196.5/ton	.10
Cryolite	$510-550/ton	.27
Copper Sulfate (basic)	$70.60/100 lb.	.71
Sulfuric Acid (West Coast)	$50-55/ton	.0275
Magnesium chloride, anhydrous	$.1275/lb.	.1275
Magnesium chloride, hydrous	$120/ton	.06
Petroleum Xylene	$.565-.57/gal.	.079

1975 Mill-Tax Calculations

$\$326 \times 10^6$ total 1975 pesticide sales [32]

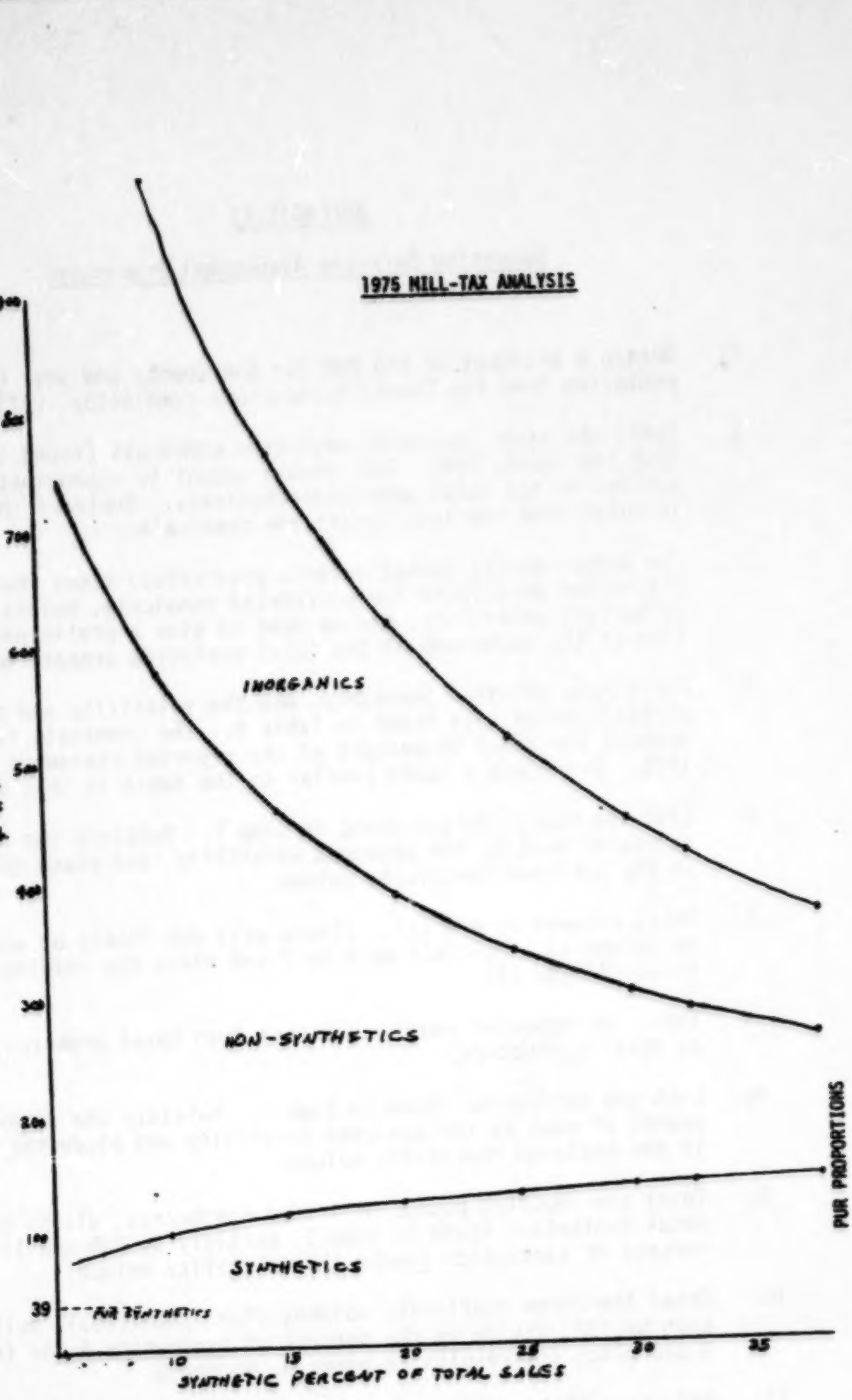
Assumptions:		**75 PUR Proportions**
$2.15/lb synthetics	organics	= 37.99%
.10/lb nonsynthetics (77¢/gal)		y = 33.03%
.15/lb inorganics		z = 28.98%

$$\frac{y}{z} = \frac{.3303}{.2898} = 1.14 \text{ (fixed)}$$

$$\text{Total} = \frac{3.26 \times 10^8}{2.15\,x + 0.1y + 0.15\,z}$$

Synthetics	Nonsynthetics	Inorganics	Total
x = .3799 1.39×10^8 lb	y = .3303 1.21×10^8 lb	z = .2898 1.06×10^8 lb	3.65×10^8 lb
x = .3250 1.35×10^8 lb	y = .3595 1.50×10^8 lb	z = .3155 1.32×10^8 lb	4.17×10^8 lb
x = .30 1.34×10^8 lb	y = .3729 1.66×10^8 lb	z = .3271 1.46×10^8 lb	4.46×10^8 lb
x = .25 1.29×10^8 lb	y = .3995 2.07×10^8 lb	z = .3505 1.81×10^8 lb	5.17×10^8 lb
x = .20 1.23×10^8 lb	y = .4261 2.63×10^8 lb	z = .3739 2.31×10^8 lb	6.17×10^8 lb
x = .15 1.14×10^8 lb	y = .4528 3.45×10^8 lb	z = .3972 3.03×10^8 lb	7.63×10^8 lb
x = .10 1.00×10^8 lb	y = .4794 4.79×10^8 lb	z = .4206 4.21×10^8 lb	10.0×10^8 lb

1975 MILL-TAX ANALYSIS



APPENDIX II

Suggested Emission Assessment Procedure

1. Obtain a printout of DFA PUR for the county and year being inventoried from the County Agriculture Commission. [17]

2. Total the major inorganic pesticide chemicals (found in Table 2) from the County PUR. This should amount to approximately 30 percent of the total pesticide chemicals. Subtract this inorganic total from the total pesticide chemicals.

3. The above results (total organic pesticides) times the appropriate factor to account for unreported chemicals, multiplied by 90 percent volatility, may be used to give a preliminary indication of the magnitude of the total pesticide organic emissions.

4. For a more detailed inventory, use the volatility and reactivity classification data found in Table 5. The chemicals listed account for about 95 percent of the reported statewide usage in 1975. Construct a table similar to the table in this appendix.

5. List the nonsynthetics found in step 1. Multiply the reported pounds of each by the assigned volatility, and place the result in the assigned reactivity column.

6. Total columns II and III. (There will not likely be anything in column I). Multiply each by 7 and place the results in boxes (1) and (2).

7. Total the reported pounds, subtract from total organics, and list as total synthetics.

8. List the synthetics found in step 1. Multiply the reported pounds of each by the assigned volatility and place the result in the assigned reactivity column.

9. Total the reported pounds of listed synthetics, divide by the total synthetics found in step 7, multiply by 100 and list as percent of synthetics (under the volatility column).

10. Total the three reactivity columns (for synthetics), multiply each by 192, divide by the percent of synthetics found in step 9 and place the results in boxes 3, 4, and 5.

11. Add boxes (1) and (4) and place the result in box (6).

12. Add boxes (2) and (5) and place the result in box (7).

13. Add boxes (6) and (7), divide by 2000 and 365 and report the result in tons/day as ROG.

14. Add boxes (3), (6), and (7), divide by 2000 and 365 and report the result in tons/day as TOG.

[Suggested Form for Pesticides Organic Gas Emission Inventory]

______________County Organic Pesticide Emissions 19__

Total Pesticides ______________ lbs.
- Inorganics ______________ lbs.
Total Organics ______________ lbs.

			Reactivity Classification		
Chemical (>1%)	lbs.	Volatility	I	II	III

Non-Synthetics

Total ________ X 7 = (1) (2)

Total Organics ________
- Non-Synthetics________
Total Synthetics________

Synthetics

________ xx.xx % of synthetics

Total Synthetics

Total Organics

$$X \frac{1.92}{.xxxx} = $$

(3)	(4)	(5)
(3)	(6)	(7)

$$ROG = \frac{(6)+(7)}{(2000)(365)} = $$ Tons/Day

$$TOG = \frac{(3)+(6)+(7)}{(2000)(365)} = $$ Tons/Day

APPENDIX III

Application of Methodologies to Kern County (San Joaquin Valley Portion)

Existing ARB Methodology:	HC T/D	HR T/D
72 Kern County: Pesticides [4]	1.7	1.4
Stationary Sources Total	112.5 (1.5%)	17.5 (8%)
Light Duty Vehicle Exhaust	28.8	21.6
All Source Total	169.9 (1%)	60.0 (2.33%)

	TOG T/D	ROG T/D
73 Kern County: Pesticides [5]	2.5	2.5
Stationary Sources Total	220 (1.1%)	135 (1.9%)
Light Duty Vehicle Exhaust	15.8	14
All Sources Total	262 (1%)	173 (1.4%)
Proposed Methodology:		
75 Kern County: Pesticides	23.87	23.63
72 Kern County: Pesticides	28	26
Other 75 Kern County Inventory Data [42]:		
Stationary Sources Total	245	170 (13.9%)
Light Duty Vehicle Exhaust	11.1	9.8
All Sources Total	273	194 (12.2%)

Comparison:

Proposed vs. existing methodologies, both applied to 1972 PUR data:

$$\frac{26}{1.4} = \boxed{\text{18.6 times}}$$

Proposed methodology applied to 1975 PUR data vs. 1973 published (corrected):

$$\frac{23.63}{2.5} = \boxed{\text{9.5 times}}$$

KERN COUNTY 1972

PESTICIDE OSG REPORT DATA

	APPS	lb.	ACRES
COUNTY TOTAL	29,436	10,105 824 92	2,958,521 92
ACRES TREATED WITH ONE OR MORE CHEM.	21,578		2,193,807.58
ACRES TREATED BY AIR			1,441,529.00
PETROLEUM			101,554.20
AROMATIC SOLVENTS	1,129	111,278 51▾	30,962.50
DISTILLATES	287	13,687.90–	38,424.90
HYDROCARBONS	411	731,132.91– 1,099,558.04–	49,217.75
OIL, UNCLASSIFIED	(365 134	680 237 20 419 313 64	12,927.50 69,573.50
XYLENE	622	51,592.04▾	48,682.10
XYLENE RANGE	534	52,094.20▾	10,096.00
✓ $Ca(OH)_2$	– 130	874,539.98	149,134.50
DEF	1,207	213,822.18▾	70,450.00
DIKAR-R	724	130,167.92	81,205.60
KELTHANE-R	757	143 572.72	20,373.33
MALATHION	177	121,722 38▾	15,285.50
Hg TREATED SEED	– 1.17	1,017,079.50	18,043.00
MINERAL OIL	120	580,414.49–	450.00
PCP	14	122,995.68	110,128.55
PHORATE	981	137.041.52▾	161,768.56
✓ SODIUM CHLORATE	– 1,415	1,263,218.17	85,035.85
✓ Sulfur	– 729	1,647,229.51	6,886.00
1,1,2 TRICHLOROETHANE	9	413,600.00▾	

↑ [illegible]

↑
– (I Petroleum Oils)
▾ (III Other Liquid Organics)

SAN JOAQUIN VALLEY 1972 PESTICIDE EMISSIONS

COUNTY	TOTAL TONS/DAY	TOTAL ORGANICS TONS/DAY	(I) PETROLEUM OILS, TONS/DAY	(II) (0.1)×(I)	OTHER (III) LIQUID ORGANICS TONS/DAY	(IV) (0.9)×(III)	TOTAL H.C. (V) (II)+(IV)	HI. REACTIVE (VI) 0.8 (V)
AMADOR	—	—	—	—	—	—	—	
CALAVERAS	—	—	—	—	—	—	—	
FRESNO	16.5	11.5	3.0	0.3	3.9	3.5	3.8	3.0
KERN 100%	13.8	8.7	3.3	0.3	1.5	1.4	1.7	1.4
KINGS	4.4	2.3	0.8	0.1	0.3	0.3	0.4	0.3
MADERA	6.2	3.8	1.5	0.2	1.5	1.4	1.6	1.3
MARIPOSA	—	—	—	—	—	—	—	—
MERCED	8.1	7.0	2.3	0.2	3.6	3.2	3.4	2.7
SAN JOAQUIN	20.6	15.3	9.7	1.0	3.9	3.5	4.5	3.6
STANISLAUS	8.4	6.9	4.2	0.4	1.4	1.3	1.7	1.4
TULARE	14.7	7.0	2.7	0.3	2.0	1.8	2.1	1.7
TUOLUMNE	—	—	—	—	—	—	—	—

(I) PETROLEUM DISTILLATES, HYDROCARBONS, UNCLASSIFIED OILS, AND MINERAL OIL. (III) AROMATIC PETRO. SOLVENTS, XYLENE, XYLENE RANG AND ALL OTHER LIQUID ORGANICS (AT 70°F) (GASEOUS)

TOP 100 PESTICIDES BY TOTAL LBS APPLIED
IN 1975 IN KERN COUNTY [17]

RANK	CHEM	TOTAL LBS	ACRES	
1	00560	1806136,51	78056.00	SULFUR
2	00765	1084484,19	35481.78	PETROLEUM OIL, UNCLASSIFIED
3	00401	470945,10	16677.00	MINERAL OIL
4	00763	434711,63	26184.50	PETROLEUM DISTILLATES
5	00536	345306,25	89792.50	SODIUM CHLORATE
6	00385	325785,85	838961.01	METHYL BROMIDE
7	00478	235277,93	101294.70	PHORATE
8	00136	234912.02	838713.41	CHLOROPICRIN
9	00445	177236,66	78733.07	OMITE-R
10	00473	172087.25	24483.00	PETROLEUM HYDROCARBONS
11	00752	121546,16	102190.82	AROMATIC PETROLEUM SOLVENTS
12	00179	113211,61	18629.00	DACTHAL-R
13	00622	95816,34	79328.50	XYLENE
14	00211	94687,60	57146.50	DITHANE
15	00459	94186,33	75763.80	PARATHION
16	00346	88593,03	63393.10	KELTHANE-R
17	00238	88290,26	43660.78	DNBP
18	00216	87548,99	69625.20	DIMETHOATE
19	00597	85037,96	73814.42	TRIFLURALIN
20	00198	72074,53	84848.90	DIAZINON
21	00230	71496,53	63901.24	DI-SYSTON-R
22	00105	68972,94	14098.83	CARBARYL
23	00052	67676,90	32579.75	AZODRIN-R
24	01673	66573,53	128813.50	SODIUM CACODYLATE
25	00293	62256,21	46254.30	FOLEX-R
26	00442	61616,38	1033.00	SULFURIC ACID
27	00190	53413,08	42633.50	DEF
28	00575	51343,40	39007.46	ALDICARB
29	00130	51064,47	12472.50	CHLORDANE
30	01728	43246,65	11200.30	2-(ALPHA-NAPHTHOXY)-N,N-DIETHY
31	00183	42673,30	2123.00	DBCP
32	00231	40831,40	15803.00	DIURON
33	00239	40712,66	5152.50	DNBP, AMINE SALTS
34	01601	35324,95	130462.51	PARAQUAT DICHLORIDE
35	00367	35004,52	5731.50	MALATHION
36	00292	32278,16	21234.00	DIFOLATAN-R
37	00534	28891,06	1986.00	SODIUM ARSENITE
38	00383	28238,94	64414.40	METHOMYL
39	00314	25500,08	30060.80	GUTHION-R
40	00786	25357,40	26962.00	MCPA, DIMETHYLAMINE SALT
41	00106	22237,39	26506.50	CARBOFURAN
42	00135	20905,95	0.00	CHLORONEB
43	00369	18891,20	11526.00	MANEB
44	01096	17357,56	4342.00	2,4-D, N-OLEYL-1,3-PROPYLENEDI
45	00418	17267,04	15291.50	NALED
46	00161	16909,56	433.00	BLUE VITRIOL
47	00531	16076,99	9440.66	SIMAZINE
48	00104	15832,70	5229.00	CAPTAN
49	00264	15156,40	5476.00	EPTAM-R
50	00358	14387,34	850.00	LIME-SULFUR

RANK	CHEM	TOTAL LBS	ACRES	
51	00464	13716,44	15104.30	PCNB
52	00166	13456,40	6946.00	FLUOMETURON
53	00384	13162.53	16242.00	METHOXYCHLOR
54	01689	12942.06	12880.00	SUPRACIDE-R
55	00335	12632,50	11076.00	IMIDAN-R
56	00394	11743,75	30676.00	METHYL PARATHION
57	00778	11594,44	1907.00	MALEIC HYDRAZIDE, DIETHANOLAMI
58	00032	11412,67	128813.50	CACODYLIC ACID
59	00806	10890,90	14099.00	2,4-D, DIMETHYLAMINE SALT
60	00490	10050,56	6702.00	PLANAVIN-R
61	00801	9820,68	9750.25	2,4-D, ALKANOLAMINE SALTS (ETH
62	00164	8941,82	1055.00	COPPER-ZINC SULFATE COMPLEX
63	01814	8842,06	24164.90	PETROLEUM DISTILLATE, AROMATIC
64	00480	8835,87	29187.50	PHOSDRIN-R
65	01154	8755,27	847.00	ALPHA-(PARA-NONYLPHENYL)-OMEGA
66	00566	8284,64	20423.67	DEMETON
67	01826	7975,43	2400.00	COPPER HYDROXIDE-TRIETHANOLAMI
68	00259	7761.19	7571.00	ENDOSULFAN
69	00151	7427,44	1393.00	COPPER HYDROXIDE
70	01081	7367,69	1556.00	DALAPON, SODIUM SALT
71	00226	7324.59	1243.50	DIPHENAMID
72	00162	7064,74	1945.00	COPPER SULFATE (BASIC)
73	00576	6999,00	4711.00	CHLOROXURON
74	00449	6889,09	2556.00	ORDRAM-R
75	00361	6833,00	6047.50	LINURON
76	01697	6523,31	7659.50	MONITOR-R
77	00158	6449,09	2361.00	COPPER OXYCHLORIDE SULFATE
78	00088	6196,89	6566.50	DYLOX-R
79	00083	5883,00	581.00	BROMACIL
80	90480	5882,64	29187.50	PHOSDRIN-R, OTHER RELATED
81	00300	5867,10	7220.00	FUNDAL-R
82	00834	5780,91	7070.00	BROMOXYNIL OCTANOATE
83	00339	5621.34	1609.00	IPC
84	00194	5569,90	0.00	DEXON-R
85	00592	5544,00	1226.00	TOK-25-R
86	01768	5520,19	2030.50	LIGNIN SULFONIC ACID (ZINC SAL
87	00677	5378,75	3977.00	CHLOROTHALONIL
88	00173	5329,92	694.00	CRYOLITE
89	00636	5117,92	6596.00	2,4-D
90	00714	5026,06	2270.00	COPPER
91	00675	4978,87	3814.60	PHENMEDIPHAN
92	00809	4773,02	7620.00	2,4-D, ISOOCTYL ESTER
93	00268	4588,82	2261.00	ETHION
94	00748	3885,04	6907.00	ALKYLARYLPOLY/OXYETHYLENE/GLYC
95	00155	3552,00	1870.00	COPPER SALTS OF FATTY AND ROSI
96	90293	3322,66	46254.30	FOLEX-R, OTHER RELATED
97	00111	3260,02	2036.00	FORMETANATE HYDROCHLORIDE
98	00502	3226.60	1815.00	PROMETRYNE-R
99	00240	2917,05	4677.00	DNBP, AMMONIUM SALT
100	00862	2706,27	4113.00	XYLENE RANGE AROMATIC SOLVENT

Kern County Organic Pesticide Emissions 1972

Total Pesticides	10,105,825	lbs.
- Inorganics	4,802,068	lbs.
Total Organics	5,303,757	lbs.

			Reactivity Classification		
Chemical	lbs.	Volatility	I	II	III
Nonsynthetics					
Petroleum Oil, Unclassified	1,099,550	90%		989,595	
Petroleum Hydrocarbons	731,133	90%		658,020	
Mineral Oil	580,414	90%		522,373	
Petroleum Aromatic Solvents	111,279	90%			100,151
Petroleum Distillates	13,688	90%		12,319	
Xylene	51,592	90%			46,433
Xylene Range	52,094	90%			46,885
TOTAL	2,639,750			2,182,307	193,469
Total Organics	5,303,757		X 7 =	15,297,869	1,356,214
- Nonsynthetics	2,639,750				
Total Synthetics	2,664,007				
Synthetics					
DEF	213,822	90%			192,440
Dikar-R	(130,168)	?			
Kelthane-R	143,573	10%			14,357
Malathion	121,722	90%			109,550
PCP	(122,996)	?			
Phorate	137,042	90%			123,338
1,1,2 Trichloroethane	413,600	90%	372,240		
TOTAL	1,029,759	(38.65%) of synthetics	372,240		439,685
Total Synthetics	2,664,007	X $\frac{1.93}{.3865}$	1,858,792		2,195,324

Total Organics	1,858,792	15,297,869	3,551,538

$$ROG = \frac{15,297,869 + 3,551,538}{(2000)(365)} = \boxed{26 \text{ Tons/Day}}$$

$$TOG = \frac{1,858,792 + 15,297,869 + 3,551,538}{(2000)(365)} = \boxed{28 \text{ Tons/Day}}$$

Kern County Organic Pesticide Emissions 1975

Total Pesticides	6,886,390	lbs.
- Inorganics	2,313,486	lbs.
Total Organics	4,572,904	lbs.

Chemical (>68,000 lbs.)	lbs.	Volatility	Reactivity Classification I	II	III
Nonsynthetics:					
* Petroleum oil, unclassified	1,084,484	90%		976,036	
* Mineral oil	490,945	90%		423,891	
* Petroleum Distillates	434,712	90%		391,241	
* Petroleum Hydrocarbons	172,087	90%		154,878	
* Aromatic Petroleum Solvents	121,546	90%			109,391
* Xylene	95,816	90%			86,234
TOTAL	2,379,590			1,946,006	195,625
Total Organics	4,572,904		X 7 =	13,622,042	1,369,275
- Nonsynthetics	2,379,590				
Total Synthetics	2,193,314				
Synthetics:					
Methyl Bromide (acres)	333,960	20%	66,792		
(other)	1,644	75%	1,233		
Phorate	235,278	90%			211,750
Chloropicrin	234,912	90%			211,421
Omite-R	177,237	90%			159,513
Dacthal-R	113,212	20%			22,642
Dithane	94,688	10%			9,469
Parathion	94,186	90%			84,767
Kelthane-R	88,593	10%			8,859
DNBP	88,290	50%			44,145

			Reactivity Classification		
Chemical (>68,000 lbs.)	lbs.	Volatility	I	II	III
Synthetics cont.					
Dimethoate	87,549	90%			78,794
Diazinon	72,075	90%			64,868
Carbaryl	68,973	10%			6,897
TOTAL	1,690,597	77.08% (of synthetics)	68,025		903,125
Total Synthetics	(2,193,314)	$\times \frac{1.93}{.7708} =$	$\boxed{170,327}$		$\boxed{2,261,328}$
Total Organics			$\boxed{170,327}$	$\boxed{13,622,042}$	$\boxed{3,630,703}$

$$ROG = \frac{13,622,042 + 3,630,703}{(2000)(365)} = \boxed{23.63 \text{ Tons/Day}}$$

$$TOG = \frac{13,622,042 + 3,630,703 + 170,327}{(2000)(365)} = \boxed{23.87 \text{ Tons/Day}}$$